A Framework for Co-located Collaborative Business Process Modelling Using Touch Technologies

By

Irene Snyman

Submitted in fulfilment of the requirements for the degree of Magister Commercii in in the Faculty of Science at the Nelson Mandela Metropolitan University

December 2013

Supervisor: Prof A.P. Calitz
Co-Supervisor: Dr B. Scholtz

Declaration

I, Irene Snyman 208093209, hereby declare that the dissertation for the degree of Magister Commercii is my own work and that is has not previously been submitted for assessment or completion of any postgraduate qualification to another University or for another qualification.

Irene Snyman

Summary

In recent years the field of Business Process Modelling (BPM) has gained increasing attention from both the business and research communities. One of the primary drivers for BPM is the improved understanding of Business Processes (BPs) and the competitive advantage gained over competitors. In addition, BPM can improve communication in an organisation and facilitate increased support for change management. BPM is a collaborative activity that needs to be carried out in a team environment, and Collaborative Business Process Modelling (CBPM) promotes improved readability, accuracy and quality of process models as well as a reduced workload for modellers. In spite of the increased popularity of CBPM, there is limited research related to the collaborative nature of the modelling tasks performed by modellers and specifically to the synchronisation of shared process models. In addition, tools and techniques to support CBPM do not support this synchronisation effectively or efficiently.

This study proposes a conceptual framework for CBPM using touch technologies in a co-located collaborative environment. The main research problem addressed by this study is that modellers experience difficulties conducting BPM activities in a co-located collaborative environment. In order to address the research problem and clarify and elaborate on the problems of CBPM, a two-fold approach was undertaken. Firstly, after an in-depth literature review, a BPM survey was designed and then sent to modellers in South African Information Technology (IT) consulting companies in order to provide a more in-depth understanding of the status and challenges of CBPM in IT consulting organisations.

The results revealed that available BPM software do not adequately cater for CBPM and software tools do not enforce versioning and synchronisation. In addition, hardware constraints were reported as well as problems with integrating different parts of the process model that the modellers were working on. The results of the survey also showed that the positive aspects of CBPM are that ideas could be shared and overall there is a better understanding of the BPs being modelled. The second part of the problem elaboration consisted of usability field studies with participants from both education and industry using a traditional popular BPM software tool, Enterprise Architect (EA). Whilst several benefits of CBPM were confirmed, several challenges were encountered, particularly with regard to the integration and synchronisation of models.

To overcome the problems of CBPM, a framework was developed that allows for co-located CBPM using tablet PCs. The framework includes a developed prototype of the BPMTouch software which runs on tablet PCs, as well as some theoretical aspects of CBPM. The BPMTouch software supports effective and efficient CBPM and the synchronisation of process models since it allows multiple modellers to work together on one BP model, with each modeller using his/her own tablet. If one modeller makes changes to the model, the changes are immediately reflected on the tablets of the other modellers since the changes to the model are updated in real time. Modellers cannot draw on the same model simultaneously, however, everyone can see what the active modeller (active participant with the green flag) is doing. Other participants can then become the active modeller and make changes to the model once the flag has been released and re-allocated.

The results from the field studies, industry surveys and usability evaluations were all incorporated into the BPMTouch software tool design and into the aspects of CBPM in order to assist with the process of co-located CBPM using touch technologies. Usability evaluations were carried out in which industry and student participants used BPMTouch to create an integrated model and simultaneously and synchronously create a process model. The evaluations of the BPMTouch prototype revealed that participants prefer this system over traditional BPM software since the BPMTouch removes the need for post modelling integration.

The theoretical contribution of the framework consists of aspects proposing that organisations should take the potential benefits and challenges of CBPM into consideration and address the Critical Success Factors (CSFs) before embarking on a CBPM project. These aspects can help with decisions relating to CBPM. The use of this framework can improve the quality of process models, reduce the workload of modellers and in this way increase the success rate of CBPM projects.

Acknowledgements

Table of Contents

List of Figures

List of Tables

Chapter 1

Introduction and Research Design

1.1. Background

In recent years, the field of Business Process (BP) management has received increased attention from organisations due to its ability to manage, transform and improve organisational operations (Hammer 2010). BP management allows organisations to build information systems (IS) which can evolve the organisation based on changes in the environment thereby assisting it, (the organisation), to stay competitive in today's fast changing markets (Jin *et al.* 2010). Business Process Modelling (BPM) forms a major part of the activities of BP management (Aleem, Lazarova-Molnar and Mohamed 2012; ABPMP 2013) and is a means of illustrating the BPs in an organisation and the relationships between them (Bandara, Gable and Rosemann 2005; McSweeney 2010).

Before new systems are implemented or crucial decisions made, organisations model their processes by using BPM (Bandara *et al.* 2005). The new system is also mapped to the organisation's processes in these models. BPM has become so prevalent and intrinsic in organisations, that in 2009 BPM (including methodology and management) was ranked first in the top ten technical skills in demand in organisations (Marsan 2009). Business analysts use BP tools to enable them to understand the processes, workflows, data and events better by using standard modelling techniques. Therefore a business analyst carries out BPM activities. Garay (2012) documented the top 10 skills required by business analysts in 2012 and conceptual modelling was the top skill required by business analysts. Hein (2013) documents the 16 Information Technology (IT) skills that are high in demand in 2013 of which the business analysis skill is 12th overall. A business analyst is also one of the top 10 IT job titles that are most in demand (ITBusinessEdge 2012).

BP models can be used as a means of communication in BP management and allow for shared understanding, automation and improvements of procedures that are carried out in organisations (Grosskopf, Edelman and Weske 2010). The increased use of BP management in recent years by numerous industries and government has led to large collections of BP

models. Conceptual models have been in use since the 1960s and used for the early identification and correction of development errors (Wand and Weber 2002). However, more recently the development of conceptual models has focussed on business processes (Davies *et al.* 2006).

The benefits of BPM have been cited by numerous studies (Havey 2005; AccuProcess 2009; Indulska *et al.* 2009a) as process quality improvement, knowledge management, improved understanding of BPs and communication. Other studies (Yanhong 2009; Amalnick *et al.* 2010) indicate that BPM is considered one of the critical success factors (CSFs) of Enterprise Resource Planning (ERP) system success. BPM is a collaborative activity (Renger, Kolfschoten and de Vreede 2008) since the stakeholders that are involved in BPM projects consist of a process owner (end user), business analyst, session facilitator, observers and a modelling expert and they all need to collaborate (Lee *et al.* 2000; Barjis 2011; Poppe *et al.* 2011). Collaborative Business Process Modelling (CBPM) has been reported as producing more accurate models and facilitating the shared ownership of processes (Barjis 2011).

Collaboration refers to the "act of working jointly" (Webster's Online Dictionary 2012). There are several definitions and understandings of the term CBPM. One use of the term CBPM is that the processes themselves can interact and collaborate between each other, especially when internal and external processes from outside a company collaborate (Ryu and Yücesan 2007). However, the term CBPM could also be defined as the collaboration of all the stakeholders involved in a BPM project (Renger *et al.* 2008; Barjis 2009; Poppe *et al.* 2011). This study will use this definition of CBPM and expand on it by describing it as the process of collaboratively drawing BP models in small teams of modellers and the ability of more than one BP modeller to draw or work on the same model simultaneously in a synchronous and co-located manner (same time and space).

BPM software tools and techniques are used in organisations globally to define and model the processes, operations and the relationships between them (McSweeney 2010; Talend 2013). BPM software is used by BP modellers in industry by either consulting companies who model for other companies or by internal modellers who model for their own company. BPM has also become an important element in ERP courses, in industry training courses and in higher education (Seethamraju 2010) and BPM software is used in these environments for learning how to draw BP models. In South Africa some Higher Education Institutions (HEIs)

(Sonteya and Seymour 2012; NMMU 2013) and companies are using modelling to define and explain their BPs.

As BPM is gaining popularity, there is a need for functional and operational BPM software (Harmon and Wolf 2011). SYSPRO Process Modelling (SPM) is a South African tool that is being used to carry out BPM in South African companies (SYSPRO 2013). A number of the top BPM software packages are Enterprise Architect (EA) from Sparx Systems (2013a), Microsoft Visio (Microsoft 2013), IBM Whebsphere (IBM 2013), AccuProcess Modeller (AccuProcess 2013), UModel (ALTOVA 2013) and Bizagi Process Modeller (Bizagi 2013). Other software solutions are available which act as reference guides to BPM where users can look up notations and rules of BPM. These solutions, however, do not allow users to draw BP models but to merely look up information about BPM notations and rules, similar to a dictionary.

There are many potential benefits of BPM, however, several challenges of BPM have also been reported by Indulska *et al.* (2009b). These challenges include problems relating to the standardisation of process models, model management, training and ease of use of the modelling tools, methodologies or notations. A further problem with BPM is that the modelling of the BPs tends to be conducted by expert modellers and they might be outside consultants and are not always from the organisation (Bandara *et al.* 2005). Experts need to have a thorough understanding of the processes, how they function, the relationships between processes and how they are used before they can be modelled.

The challenges and problems of CBPM identified by Barjis (2011) are related to the fact that several stakeholders are involved in a modelling session and time management might be difficult. There is limited touch technology available which supports BPM and particularly CBPM. ProcessCraft is BPM software which runs on all modern operating system platforms, for example Microsoft Windows, Mac OSX, Android, iOS and Linux and on most devices such as computers, tablet PCs and the Microsoft Surface (Tabtou Ltd. 2012). At the time of this study no tool could be found which provides synchronised touch technology for CBPM in co-located environments. ProcessCraft runs on several platforms, however, it does not allow for multiple users to model synchronously and therefore easy integration of models cannot be accomplished. In addition, limited research has been done on the usability of these tools and on Critical Success Factors (CSFs) and aspects for implementing CBPM.

No comprehensive frameworks have been identified which provide the software on a touch tablet and which allows for co-located CBPM with several modellers participating simultaneously. A framework can be defined as "parts of a particular system" or "a set of beliefs, ideas or rules that are used as the basis for making judgements or decisions" (Oxford University Press 2013a). In this study, the latter definition will be used. A framework for co-located CBPM using touch technologies is proposed by this study. The framework includes the BPMTouch software developed by the author as well as theoretical aspects to assist organisations with carrying out CBPM.

1.2. Research Problem

BPM is a collaborative activity that should be carried out synchronously and simultaneously with more than one process modeller and other stakeholders present and working on the same process model. Various BPM software tools have been developed but at the time of this research, in spite of a search of BPM literature (Section 3.3), no studies on software tools which support both collaboration for BPM and touch technology could be found. In addition only one BPM software for touch could be identified, namely, ProcessCraft (Tabtou Ltd. 2012).

Software tools which support both collaboration and touch input, for example ProcessCraft (Tabtou Ltd. 2012), have been developed; however, from literature it is evident that not more than one modeller can conduct process modelling synchronously and simultaneously on the same model in a co-located collaborative environment. These software tools typically exist independently of each other. Whilst several studies (Barjis 2011; Dollmann *et al.* 2011; Lee *et al.* 2000; Rittgen 2008) have proposed CBPM frameworks and tools, none of them have combined all of the components that are deemed important in a CBPM software tool and none of them cater for touch input.

The proposed research problem of this study is:

> ***Modellers experience difficulties conducting collaborative business process modelling activities in a co-located environment.***

1.3. Relevance of Study

Successful BPM is a very important issue in organisations as the consequences can be large, leading to the implementation of new BPs, Information Technology (IT) systems or organisational structures (Bandara *et al.* 2005). There are many BPM tools on the market, for example Microsoft Visio, Enterprise Architect and Bizagi Process Modeller that can be used on standard desktop PCs, whilst a limited number can be used on mobile and touch devices. There is a lack of studies done on BPM software tools, particularly in terms of touch technology for BPM and CBPM. This study aims to bridge that gap by focussing on CBPM for touch technology on tablet PCs.

Tablet PCs have been shown to be very successful for use in collaborative environments (Twinning *et al.* 2005). According to BusinessTech the International Data Corporation (IDC) forecasts that 172 400 000 tablets will be shipped worldwide in 2013 while NPD forecasts that 240 000 000 tablets will be shipped worldwide in 2013 (BusinessTech 2013a). Sales from Kalahari.com and Takealot.com were also discussed indicating that in both cases, with online sales, tablet PCs outsold desktop PCs. The traffic going to Kalahari.com via tablet devices has increased over 300% from November 2011 to November 2012, however, in total most of the traffic comes from PC and mobile. Incredible Connection, a physical retail chain shop indicated that for every tablet sold, two laptops were sold, however, the chief executive indicated that this gap is shrinking. The global forecast is that tablet sales will be more than PC sales in 2013, however, that will not be the case in South Africa as two laptops were sold for every tablet in December 2012.

1.4. Thesis Statement

The proposed thesis statement is as follows:

> *A framework for co-located collaborative business process modelling (CBPM) using touch technologies can improve the efficiency, effectiveness and user satisfaction of business process modelling activities.*

1.5. Research Objectives

The Main Research Objective (RO$_M$) of this study is:

> ***To design a framework that can be used for co-located collaborative business process modelling (CBPM) using touch technologies.***

Several secondary objectives have been identified, namely:

RO$_1$:   Identify the benefits and challenges of CBPM.

RO$_2$:   Identify the critical success factors and success measures of CBPM.

RO$_3$:   Identify technologies that can be used for collaboration.

RO$_4$:   Define the objectives and requirements of a CBPM software tool (BPMTouch).

RO$_5$:   Identify the usability criteria and design considerations of current CBPM tools.

RO$_6$:   Evaluate the software prototype (BPMTouch) for CBPM.

1.6. Research Questions

The Main Research Question (RQ$_M$) of this study is:

> ***What framework can be used to support co-located collaborative business process modelling using touch technologies?***

The study will focus on solving this question and providing a validated response. Subsidiary research questions are listed in Table 1.1. An in-depth literature study will be carried out to answer the underlying research questions (RQ$_1$, RQ$_2$ and RQ$_3$) in Chapters 2 to 4. These results will then be verified by means of an industry survey. The results of a pilot study, field study and extant systems analysis will be taken into consideration to answer RQ$_4$ in Chapter 4. A literature study and questionnaires will be used to answer RQ$_5$ in Chapter 5 and RQ$_6$ in Chapter 6.

Table 1.1: Research questions and data gathering methods

Secondary Research Questions (RQ)	Research Objective (RO)	Data Gathering Method	Chapter
RQ$_1$: What are the benefits and challenges of CBPM?	RO$_1$: Identify the benefits and challenges of CBPM.	Literature study Survey	Chapters 2 and 3
RQ$_2$: What are the critical success factors and success measures for CBPM?	RO$_2$: Identify the critical success factors and success measures of CBPM.	Literature study Survey	Chapters 2 and 3
RQ$_3$: What technologies can be used for collaboration?	RO$_3$: Identify technologies that can be used for collaboration.	Literature study	Chapter 4
RQ$_4$: What are the objectives and requirements of a software tool (BPMTouch) for CBPM?	RO$_4$: Define the objectives and requirements of a CBPM software tool (BPMTouch).	Pilot study Field studies Extant system analysis	Chapter 4
RQ$_5$: What are the usability criteria and design considerations of current CBPM tools?	RO$_5$: Identify the usability criteria and design considerations of current CBPM tools.	Literature Study Questionnaires	Chapter 5
RQ$_6$: How can software for CBPM be evaluated?	RO$_6$: Evaluate the software prototype (BPMTouch) for CBPM.	Literature study Questionnaires	Chapter 6

1.7. Scope and Envisioned Contribution

A framework can be defined as "parts of a particular system" or "a set of beliefs, ideas or rules that is used as the basis for making judgements or decisions" (Oxford University Press 2013a). A conceptual framework for co-located CBPM using touch technologies will be designed. This framework will consist of CBPM software that can be used on a touch-based technology. The software will allow multiple users to interact synchronously on one model. Only one user will be able to provide input to the model at a time, however, the changes will be visible by all the other participants as they occur. The framework will also include aspects that should be taken into consideration when undertaking a CBPM project. These aspects will include the benefits, challenges, success measures and CSFs for CBPM. The software tool

will be a proof-of-concept prototype and will only cater for a subset of elements in the Business Process Model and Notation (BPMN).

The research community will benefit from the theoretical contribution of this study which will consist of aspects and CSFs for CBPM. These aspects will be empirically validated by a survey of modellers in South African organisations. A practical contribution will also be made in terms of the CBPM software prototype that can be used by companies for business and for educational purposes to promote and support effective and efficient CBPM. The study will include evaluations of the prototype but due to time limitations, the scope of the study will not include an evaluation of the entire framework.

1.8. Limitations of the Study

Due to time constraints, the majority of participants used for the field study of traditional BPM software tools will consist of BPM students in a South African HEI and some of the participants will be from industry. This is a possible limitation since students do not have any experience in the modelling industry, but participants from industry might provide more relevant feedback regarding the problems with BPM tools since they have more experience in this field. Therefore, a survey of CBPM challenges will be undertaken by modellers in the IT industry to counter this limitation. In addition, both industry participants and students will be evaluating the proposed BPMTouch software prototype.

1.9. Ethical Considerations

This study requires students from the university and people from industry to evaluate BPM software and to complete questionnaires/surveys and ethical clearance is needed for this purpose. Participants will be given consent forms, an explanation of the study and the opportunity to withdraw at any stage during the study. Ethical clearance was approved by the Nelson Mandela Metropolitan University (NMMU) Human Research Ethics Clearance Committee (REC–H). The ethics clearance number for this study is H12-SCI-CS-019.

1.10. Research Methods

Positivism is a position that is derived from natural sciences and posits that information can only be merited as knowledge if it can be confirmed by the senses (Bryman 2012). It also requires testable hypotheses to be created, objective thinking and knowledge to be found by gathering facts. Realism is similar to the positivist approach as it also believes that natural sciences should be applied to the collection and explanation of data and also that reality is detached from the scientist's description of it. The main difference is that with the realist approach, a scientist's concept of a reality is simply a way to understand that reality, whereas the positivist approach posits that the scientist's concept of reality directly reflects that reality. Interpretivism contradicts positivism by relying on the scientist's understanding of social interactions and interpreting information as a product thereof. The thought process used is one of "common-sense", which directly opposes the views of positivism.

This study will, however, not be following positivism, realism or interpretivism research methods but instead will follow the Design Science Research (DSR) methodology (Figure 1.1) as it is an iterative approach which revolves around defining and identifying a problem that can be addressed by the development of an artifact (Johannesson and Perjons 2012). The focus will therefore be on identifying a problem and the people who have the problem and solving the problem by producing an artifact. A literature study, initial pilot study, post-test questionnaires, a survey and an evaluation of a touch prototype will form part of the research strategy used throughout the course of this study (Section 1.10.1). This study will also be based on the DSR methodology and follow several guidelines of DSR (Section 1.10.2).

1.10.1.   Research Strategy

A literature study will be conducted throughout the entire research study to determine the importance and the challenges of BPM and the collaborative nature of BPM. Other topics that will be incorporated into the literature study include collaboration, interaction techniques and collaborative technologies. A theoretical framework consisting of aspects for CBPM will be derived.

A pilot study of existing problems and solutions for BPM will be carried out with student and industry participants of a BP management course at the Department of Computing Sciences at NMMU. Participants will be required to model a scenario and fill in questionnaires upon completing the model.

The second study will be a survey that will be sent out to industry participants, the results of which will empirically validate the theoretical aspects of the framework for CBPM. A field study will also be carried out in which second year BPM students from the Department of Computing Science at NMMU will complete two BPM assignments as part of their course work. The students will be required to complete a post-test questionnaire that will be focussed on the usability of the tool. A framework will be designed, based on theory and the pilot study and a field study, which will contain a proof-of-concept prototype and aspects of CBPM.

The third study will be user evaluations of the prototype. The evaluations will be carried out by four pairs of student participants and five pairs of industry participants who will complete a post-test questionnaire. The questionnaires will comprise several Likert rating scale questions and open-ended questions. All of the data collected from the questionnaires will be statistically analysed or thematically analysed and the results reported.

1.10.2.   Research Methodology

A DSR methodology was created based on Design Science literature (Peffers *et al.* 2007). The DSR methodology can serve as a framework for conducting research that is based on Design Science (Figure 1.1). The activities in the DSR methodology process are:

- **Activity 1: Identify problem and motivate**

  Activity 1 involves creating a problem definition and justifying the importance of a solution.

- **Activity 2: Define objectives of a solution**

  This activity defines the objectives of the solution based on the problem definition and knowledge.

- **Activity 3: Design and development**

  The design and development activity involves the design and creation of the artifact.

- **Activity 4: Demonstration**

  The demonstration activity demonstrates how the artifact will be used to solve the defined problem. The demonstration can be in experiments, case studies or any activity that is deemed appropriate.

- **Activity 5: Evaluation**

  The evaluation activity measures if, and how well, the artifact provides a solution to the defined problem. In this step the objectives defined in Activity 2 should be compared to the recorded results. Upon completion of this activity, researchers must analyse the results and decide if it is necessary to iterate back to Activity 3 (to improve the artifact) or to proceed to Activity 6.

- **Activity 6: Communication**

  The last activity communicates the importance of the problem, the solution (artifact), the design rigour and the effectiveness of the artifact to relevant audiences.

With DSR it is not necessary to start at the first activity (Activity 1). Researchers can start the iteration at any activity and work outwards, based on the study at hand.
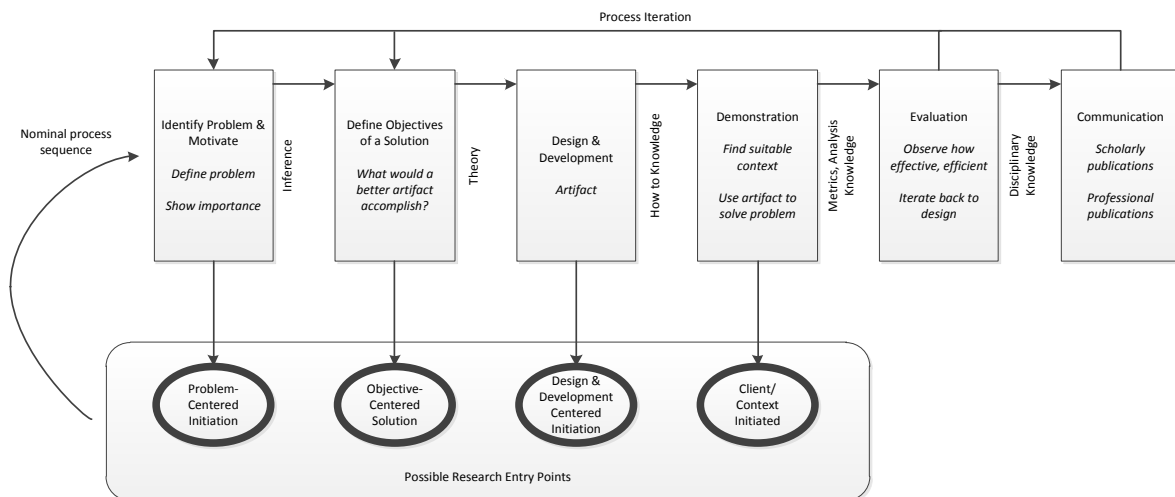
Figure 1.1: Design Science Research (DSR) methodology process adapted from Peffers *et al.* (2007)

Johannesson and Perjons (2012) have also documented research strategies in the DSR methodology (Figure 1.2). A problem should be explored, the artifact (which is the solution to the problem) outlined and the requirements need to be defined. The artifact must then be designed and developed.

Once the artifact is developed and functional it should be demonstrated and evaluated. This is similar to the DSR process (Figure 1.1) proposed by Peffers *et al.* (2007).
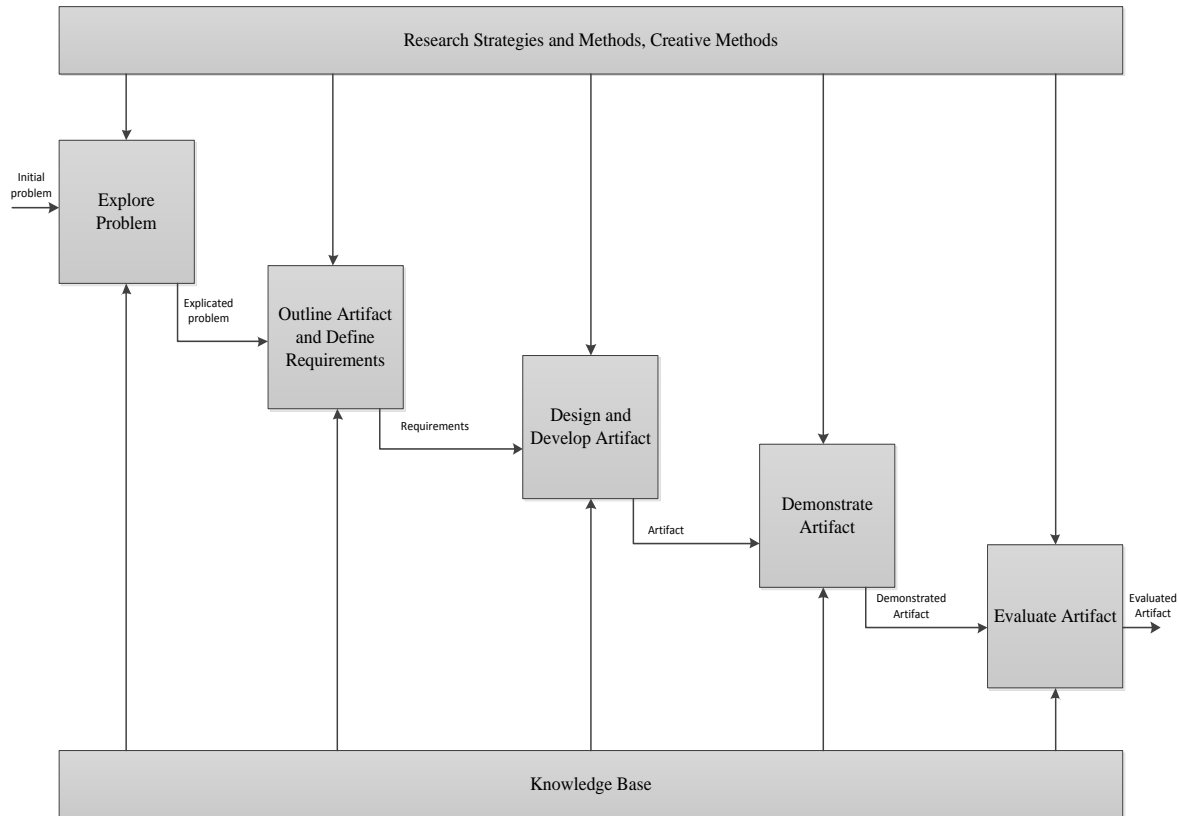
Figure 1.2: Design Science method diagram adapted from Johannesson and Perjons (2012)

The DSR methodology will be used to carry out this study. Seven guidelines (Table 1.2) to aid in design-science research in information systems have been identified (Hevner *et al.* 2004; Hevner and Chatterjee 2010). The central focus of design-science research is that understanding and knowledge of a business need and the solution to the need are necessary in developing an artifact. Therefore, design-science requires the building of an artifact which is guideline one, for an identified business need (problem relevance) which is the second guideline. The developed artifact needs to be evaluated in order to demonstrate its purpose (guideline three). Research contributions need to be made when using the design-science methodology. These contributions can only be made if the identified need is solved in a way that is more efficient and effective than an existing solution, or solving an unsolved need (guideline four). The artifact must be produced by applying rigorous methods in the construction and evaluation of the artifact (guideline five). Throughout the research a search process will be created as a problem has been identified and the researcher needs to search for

a solution until the problem is solved in an effective manner (guideline six). Lastly, the results of the research need to be conveyed to both technical- and managerial-orientated audiences (guideline seven).

Table 1.2: Research guidelines for Design-Science (Hevner *et al.* 2004)

Guideline	Description
Guideline 1: Design as an Artifact	Design-science research must produce a viable artifact in the form of a construct, a model, a method, or an instantiation.
Guideline 2: Problem Relevance	The objective of design-science research is to develop technology-based solutions to important and relevant business problems.
Guideline 3: Design Evaluation	The utility, quality, and efficacy of a design artifact must be rigorously demonstrated via well-executed evaluation methods.
Guideline 4: Research Contributions	Effective design-science research must provide clear and verifiable contributions in the areas of the design artifact, design foundations, and/or design methodologies.
Guideline 5: Research Rigor	Design-science research relies upon the application of rigorous methods in both the construction and evaluation of the design artifact.
Guideline 6: Design as a Search Process	The search for an effective artifact requires utilizing available means to reach desired ends while satisfying laws in the problem environment.
Guideline 7: Communication of Research	Design-science research must be presented effectively both to technology-oriented as well as management-oriented audiences.

Rigorous methods are used to construct and evaluate the design artifact and DSR requires that research rigour be applied throughout the study. Research rigour will be applied by following several approaches. A survey of South African consulting organisations will be carried out. The results of this survey along with literature identified will be used to create the framework for CBPM. A field study with two assignments will also be conducted to gather data that can be used to assist with the design of the software tool. A software tool will then be developed and form part of the framework. The software tool (prototype) will be evaluated by both participants from industry and students.

1.11. Design Science Research Methodology and Dissertation Structure

The DSR process will be followed throughout this study, and the research guidelines of this process (Table 1.2) will be followed. The dissertation is structured according to the structure and flow of the DSR methodology. This section combines the DSR methodology and the

research guidelines and provides an overview of how the study will be completed according to this methodology. The dissertation structure is summarised together with the DSR methodology in Figure 1.3 and each chapter is mapped to the relevant DSR methodology guideline and activity. The chapter layout diagram (Figure 1.4) is presented at the end of the chapter and represents the flow of the dissertation. In this diagram each chapter is mapped to the respective DSR methodology guideline and activity, as well as the research objectives for the chapter. The research instruments used in each chapter are also shown as well as the deliverables from the chapter. The structure of this study consists of seven chapters which are:

Chapter 2: Business Process Modelling

This chapter will be based on activity one (identify the problem and motivate) and it will introduce and investigate the concept of BPM further and how it is used in education and industry. An analysis of the benefits, CSFs, measures and challenges of BPM will also be provided. An initial framework (artifact), based on the literature findings and partial answers to RQ_1 and RQ_2, will be presented at the end of Chapter 2.

Chapter 3: Problem Identification of Collaborative Business Process Modelling

Chapter 3 is also based on activity one (identify the problem and motivate) and the research problem for this study is that *Modellers experience difficulties conducting CBPM activities in a co-located environment.* This chapter will use research rigour to identify and explore the problem in more detail by means of a pilot study and a survey. The survey results of both of these investigations will be discussed here and an updated framework will be presented at the end of this chapter.

Chapter 4: Objectives of a Collaborative Business Process Modelling Touch Solution (BPMTouch)

Once the problem has been fully investigated and motivated (Chapters 2 and 3), activity two can be undertaken. Chapter 4 will therefore be based on activity two (define objectives of a solution), in which the high-level objectives of the touch solution as well as the functional and non-functional requirements of the touch solution will be documented. Lastly, the hardware that can be used for collaboration is also discussed.

Chapter 5: Design and Development of the BPMTouch Software Tool

Chapter 5 will be based on activity three (design and development). The chapter will identify the research materials and usability metrics used for the study as well as discuss the field study. Research rigour will be applied in this chapter to design and construct the BPMTouch software tool (prototype). The design of the BPMTouch software tool and the development process followed will be discussed.

Chapter 6: BPMTouch Evaluation

Chapter 6 will be based on activity four and five (demonstration and design evaluation). The artifact (BPMTouch software tool) will be demonstrated to evaluation participants before they evaluate the prototype. The prototype evaluations and results will be discussed in this chapter. The effectiveness, satisfaction, usability and efficiency of the prototype will be evaluated by means of observation, a video camera and post-evaluation questionnaires. An updated framework based on the evaluation results will be presented at the end of the chapter.

Chapter 7: Conclusion and Recommendations for Future Research

Chapter 7 will be based on activity six (communication, research contributions and research rigour). The findings of the study will be discussed in this chapter. This chapter will be the concluding chapter that ties everything together. Future work will also be discussed and the final framework will be presented here.

Process Iteration

Activity 1 Identify Problem & Motivate (Peffers *et al.* 2007) Explore Problem (Johannesson and Perjons 2012)	Activity 2 Define Objectives of a Solution (Peffers *et al.* 2007) Outline Artifact and Define Requirements (Johannesson and Perjons 2012)	Activity 3 Design & Development (Peffers *et al.* 2007) Design and Develop Artifact (Johannesson and Perjons 2012)	Activity 4 Demonstration (Peffers *et al.* 2007) Demonstrate Artifact (Johannesson and Perjons 2012)	Activity 5 Evaluation (Peffers *et al.* 2007) Evaluate Artifact (Johannesson and Perjons 2012)	Activity 6 Communication (Peffers *et al.* 2007)
Chapters 2 and 3	**Chapter 4**	**Chapter 5**	**Chapter 6**	**Chapter 6**	**Chapter 7**

Inference — Theory — How to Knowledge — Metrics, Analysis Knowledge — Disciplinary Knowledge

Guideline 5: Research Rigour (Hevner *et al*. 2004)

Guideline 2: Problem Relevance (Hevner *et al.* 2004)

Guideline 6: Design as a Search Process (Hevner *et al.* 2004)

Guideline 3: Design Evaluation (Hevner *et al.* 2004)

Guideline 1: Design as an Artifact (Hevner *et al.* 2004)

Guideline 4: Research Contributions (Hevner *et al.* 2004)

Guideline 7: Communication of Research (Hevner *et al.* 2004)

Figure 1.3: Chapter layout combined with DSR methodology
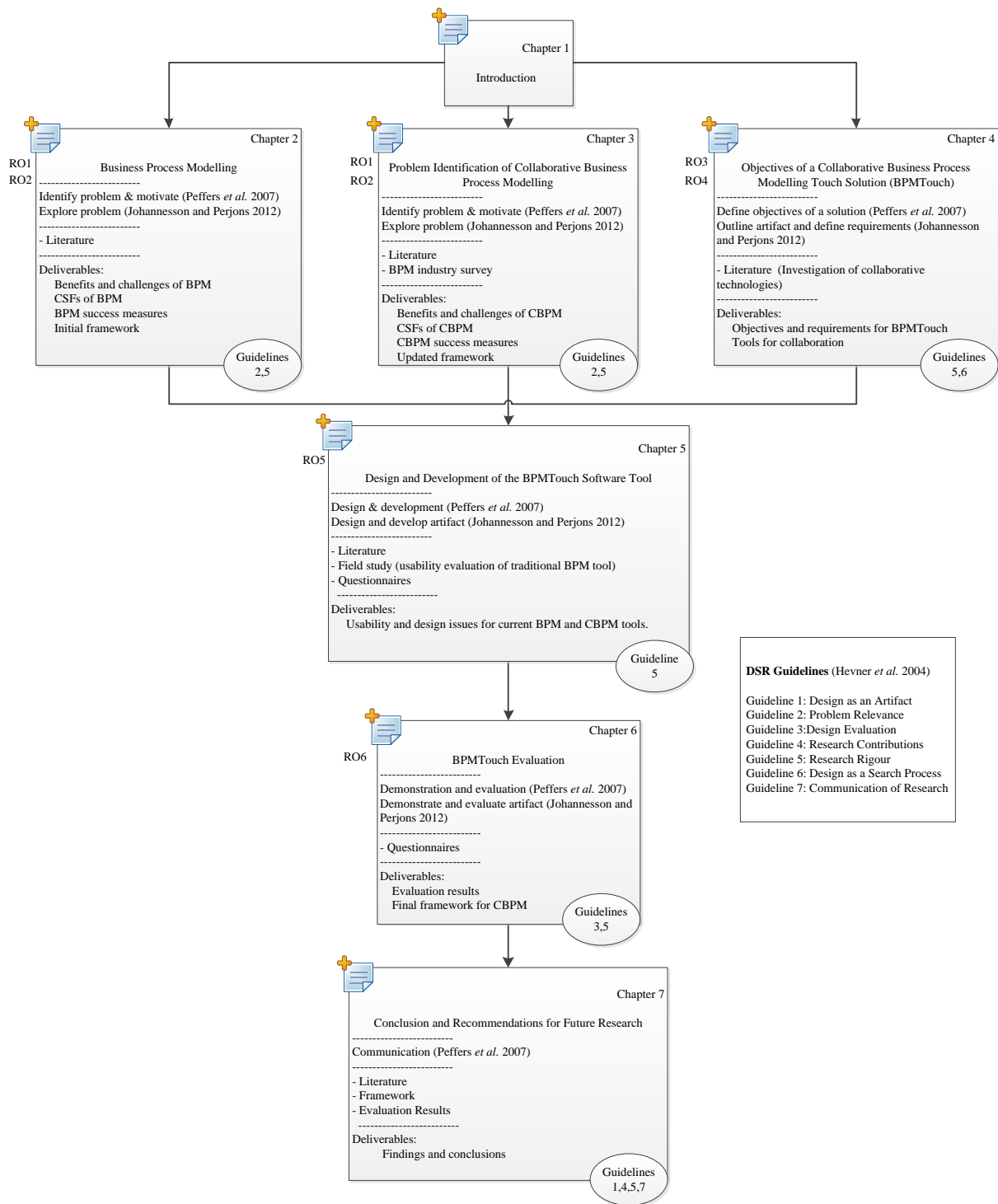
Figure 1.4: Chapter layout

Chapter 2

Business Process Modelling

2.1. Introduction

The research problem identified in Chapter 1 is a twofold problem, since both BP modellers in industry and those drawing models as part of the education process or training, struggle with CBPM (Barjis 2011). The first activity in DSR involves creating a problem definition in more detail and justifying the importance of a solution (Peffers *et al.* 2007). In order to identify the problem more clearly and to motivate the research, it is important to examine the field of CBPM in more detail and to explore the challenges encountered by modellers in both industry and educational environments. The two research questions partially addressed in this chapter are:

RQ₁: "What are the benefits and challenges of CBPM?"
RQ₂: "What are the critical success factors and success measures for CBPM?"

The two research objectives *"Identify the benefits and challenges of CBPM"* and *"Identify the critical success factors and success measures of CBPM"* are therefore also only partially fulfilled in this chapter. In order to investigate the problems regarding CBPM, the field of BPM and its related issues need to be addressed first. For this reason the questions are only partially addressed in this chapter and the collaborative aspect of BPM in each research question will be addressed in Chapter 3.

A layout of Chapter 2 and the research objectives and deliverables achieved from this chapter are shown in Figure 2.1. The field of BP management incorporates several knowledge areas (Section 2.2). BPM can be carried out by adhering to several standards and there are many programming BPM languages available for BPM (Section 2.3). In order to answer research question one (*RQ₁*), the benefits and challenges of BPM have to be investigated in detail (Section 2.4). If certain CSFs are taken into account, these can be used to improve the success of BPM projects as well as CBPM projects (Section 2.5). Section 2.6 will propose an initial framework and Section 2.7 will conclude the chapter.

Chapter 1	**Chapter 2**	Chapter 3	Chapter 4	Chapter 5	Chapter 6	Chapter 7
Introduction	**Business Process Modelling**	Problem Identification of Collaborative Business Process Modelling	Objectives of a Collaborative Business Process Modelling Touch Solution (BPMTouch)	Design and Development of the BPMTouch Software Tool	BPMTouch Evaluation	Conclusion and Recommendations for Future Research

2.1. Introduction

2.2. Business Process Management and Modelling

2.3. BPM Languages and Software Tools

2.4. Benefits and Challenges of BPM

2.5. Critical success Factors (CSFs) and Success Measures of BPM

2.6. Framework for BPM

2.7. Conclusion

Research Objectives

Deliverables

RO₁: Identify the benefits and challenges of CBPM.

RO₂: Identify the critical success factors and success measures of CBPM.

Benefits of BPM

CSFs for BPM

Challenges of BPM

Success Measures for BPM

Figure 2.1: Chapter 2 layout and deliverables

2.2.   Business Process Management and Modelling

A BP is a collection of activities that are carried out due to an event being triggered to reach a goal (Harmon 2007; García *et al.* 2008; Ko 2009; McSweeney 2010). A BP can also be seen as a guide used to accomplish a certain task in a business environment (Webster's Online Dictionary 2012). Processes transform inputs (events) into outputs to meet customer requirements (Hammer and Champy 1993). BPs are important to an organisation and form part of the corporate assets and differentiators in the competitive business environment (Seethamraju 2010). Effective BPs are essential in countries such as South Africa which want to expand on their global trade (Sonteya and Seymour 2012).

Business processes are triggered by means of an event taking place in an organisation (Dayal, Hsu and Rivka 2001). Events can be for example anything from an invoice to a payment request. Once the BP is triggered, rules are followed in order to complete the process. Rules can trigger sub-processes and resources (inputs) which are allocated to these BPs. The resources include departments within an organisation whose focus is to complete the task required for the BPs to continue or to reach a completed state. All of this forms part of the method that is used to carry out the BP. A process description is a textual representation of the inputs, outputs, methods, rules and policies used to conduct a BP (Dayal *et al.* 2001).

The organisation's processes are modelled and then mapped onto and compared with the processes supported by the ERP system. ERP systems are systems that integrate and automate corporate activities that include financial, human resource, supply and manufacturing modules (Fotini, Anthi-Maria and Euripidis 2008). Modellers, designers and programmers try to match the processes so that the best possible ERP solution for the organisation can be implemented. In some situations the organisation has to modify its processes and in other situations the ERP system to be implemented is modified to suit the organisation. According to Amalnick *et al.* (2010) Business Process Reengineering (BPR) is an important success factor for ERP implementation projects and Yanhong (2009) states that BP rebuilding or modelling is one of the critical success factors in ERP projects.

Understanding and transforming BPs is an essential requirement for organisations and therefore education that incorporates a cross-disciplinary way of teaching BPs is vital. Employers complain that university graduates do not possess adequate process management

skills and capabilities and are not prepared to work in process-centric environments (Seethamraju 2010). There is definitely a need for BPM knowledge in South Africa (Ramburn, Seymour and Gopaul 2013) and a need for BP education globally (Seethamraju 2010).

Process modelling and BP management courses are generally not offered at university level and are the responsibility of the IT or Management Information Systems departments in organisations (Seethamraju 2010). Even though BPM is limited at university level, modelling is still taught and evidence of this can be found in literature (Chiorean, Ober and Petrascu 2011; Combemale *et al.* 2011; Whittle and Hutchinson 2012). The Department of Computing Sciences at NMMU, South Africa, offers three modules that incorporate the study of BPs, BPM and BP management (NMMU 2013). The modules are *Business Process Modelling 2.1, Enterprise Resource Planning 3.1* and *Enterprise Resource Planning 3.2*.

The Association of Business Process Management Professionals (ABPMP) is a non-profit organisation that focusses on the improvement of BP management concepts and practices (ABPMP 2013). The ABPMP has a BP management Common Body of Knowledge (CBOK) with nine knowledge areas (Figure 2.2). The knowledge areas are (McSweeney 2010; ABPMP 2013):

- Business Process Management;
- Process Modelling;
- Process Analysis;
- Process Design;
- Process Performance Management;
- Process Transformation;
- Process Management Organisation;
- Enterprise Process Management; and
- Business Process Management Technologies.

Figure 2.2: Business process management: Common Body of Knowledge (CBOK): knowledge areas (ABPMP 2013)

BPM forms a vital part of BP management (Aleem *et al.* 2012). BP management contains the definition of BP management and emphasises the fundamental concepts of BP management (McSweeney 2010). BP management includes five areas: process modelling, process analysis, process design, process performance management and process transformation. Process modelling consists of the expertise and processes that allow people to communicate, understand, manage and measure the components of BPs. Process analysis includes the understanding of BPs and the effectiveness and efficiency of the BPs. Process design involves the planning of how BPs function, are measured and administered. Specifications of the BPs within the context of the organisation's goals are also created in this knowledge area. Process performance management involves the formal monitoring of the executed processes as well as tracking the results in order to deduce the efficiency and effectiveness of the executed BP. The results are used for decision making to determine whether processes should be improved or retired and whether new processes are necessary to reach the strategic goals of the organisation. Process transformation is carried out in this knowledge area within the context of a BP lifecycle.

Process Management Organisation incorporates the individual roles, responsibilities and the reporting structure that is necessary to support the organisation. Enterprise process management is a means by which processes portfolio initiatives are managed and evaluated. Enterprise process management includes BP frameworks, tools to assess the BP management maturity levels and process integration across the organisation. BP management technologies

revolve around BP management that is supported by technology and includes BP management tools, technologies, methodologies, standards and new trends.

Workflow is related to the automating of BPs in organisations (Georgakopoulos, Hornick and Sheth 1995; Hollingsworth 1994; Weske 2012). Workflows can describe the tasks and information involved in the BPs at conceptual levels or at a level at which the human and system functionality requirements can be specified (Georgakopoulos *et al.* 1995; Weske 2012). Tasks can be performed by humans, software or by both humans and software. Workflows also indicate in which sequence the task has to be carried out and the conditions which trigger the start of the tasks. A Workflow Management System (WFM) is a system that enables the automation of BPs by managing the sequence of activities and the human and IT resources required in these activities (Hollingsworth 1994).

To identify problems within an organisation's processes a gap model can be used (Harmon 2007). In a gap model, organisations indicate what their current processes are (as-is process), the means of measuring the performance of the process and how things are being done. This is compared with how the organisation would like their processes to be (to-be process) and the means of measuring these processes and how the processes will be carried out. When this gap is identified, organisations can try to overcome it by improving the relevant processes (McSweeney 2010).

Typically, an organisation's value chain is the largest process in an organisation and is typically a level 0 process. This means that the value chain contains sub-processes within its higher level process. These processes would then be termed level 1 process and can, in turn, have sub-processes within them which will be termed level 2 processes and so on. A super-process is a process that contains a sub-process.

A diagram of a BP can be referred to as a process map, workflow diagram, a BP model or an activity diagram (Harmon 2007). A process contains activities (or sub-processes) and events. Upstream processes are processes that are referred to as supplier processes whereas downstream processes are referred to as customer processes. These processes can provide input to the organisation process under study and output is generated for a different process (Figure 2.3).
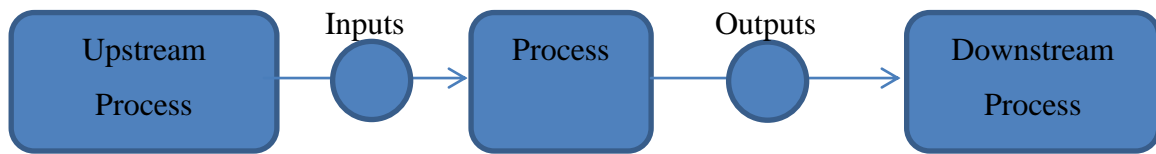
Figure 2.3: Basic elements in BPM (Harmon 2007)

The circles represent events that take place. An event is something that happens at a specific point in time and triggers a process, whereas a process takes a certain amount of time to complete. A process usually contains a start event and an end event. The way the elements of a model are represented varies depending on the process modelling language and business rules defined by the organisation.

2.3. BPM Languages and Software Tools

Different BPM languages exist with different rules and shapes representing the elements in a BP (Grossmann, Schrefl and Stumptner 2008). Users and creators of BP models use different modelling notations relating to their definition and understanding of a BP and a BP model (Lindsay, Downs and Lunn 2003).

Event-driven Process Chains (EPC) is a modelling language used in Architecture of Integrated Information Systems (ARIS) and SAP R/3 (Grossmann *et al.* 2008). The EPC modelling technique has proven to be successful and is used often in the modelling environment. EPCs are made up of three different elements, namely, functions (activities), logical connectors and events. An event requires a trigger before an activity is carried out. The logical connectors used within EPC models include *OR*, *XOR* and *AND*. Unified Modelling Language (UML) is a standard for modelling in the software industry (Object Management Group 1999; Object Management Group 2012). Two nodes are included in UML 2.0 namely activities and actions (Grossmann *et al.* 2008). Activities can comprise sub-activities, whereas actions do not contain sub-actions. UML 2.0 allows for models to incorporate routing by means of various nodes, including fork nodes, decision nodes, merge nodes and join nodes.

Business Process Model and Notation (BPMN) is another process modelling standard language developed by the Business Process Management Initiative (BPMI) and has been adopted as a standard notation to be used for BPM by the BP community as it incorporates the best aspects of other notations (White 2004b). The aim of creating the BPMN was to create a

notation that can be understood by all the stakeholders of a process model (Grossmann *et al.* 2008; White 2004b). In 2005 the BPMI and the Object Management Group (OMG) merged and the OMG therefore maintains the BPMN standard, amongst other standards (Object Management Group 2008).

The BPMN comprises four groups of elements which are used to make up the different aspects of a BP model (White 2004a). The groups are: flow objects; connecting objects; swim lanes and artifacts. There are three types of flow objects (White 2004a):

- Event;
- Activity; and
- Gateway.

An event is represented by a circle shape and is usually started by a trigger and can either be a start, intermediate or end event (Grossmann *et al.* 2008). Types of events (Figure 2.4) include: basic, message, timer, rule, exception, cancellation, compensation, link, multiple and termination (Havey 2005).

Start	Intermediate	End	Name
○	◎	○	Basic
✉	✉	✉	Message
⏲	⏲		Timer
▦	▦		Rule
	Ⓝ	Ⓝ	Exception
	⊗	⊗	Cancellation
	⧯	⧯	Compensation
➝	➝	➝	Link
✴	✴	✴	Multiple
		◍	Termination

Figure 2.4: BPMN events (Havey 2005)

An activity (Figure 2.5) represents work that has been or needs to be completed and can either be a task or a sub-process activity (White 2004b). Activities are represented by a rectangle with round edges (Havey 2005). When a sub-process (child process) activity is drawn in a higher level process (parent process), the sub-process includes a plus sign (+).

25

This sign indicates that the sub-process is in a collapsed state and the extended process is drawn in a different diagram.
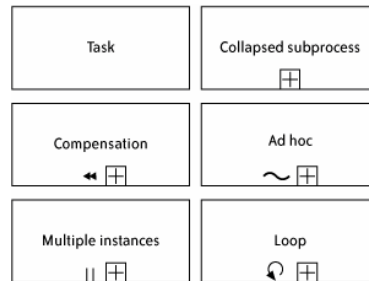
Figure 2.5:BPMN activities (Havey 2005)

Gateways are represented by diamond shapes and are used for decision making and to control the sequence flow in the process (Ottensooser *et al.* 2012; White 2004b). Gateways indicate where the process splits and joins again, similar to the programming structures, switch and if-then (Havey 2005). Several different types of gateways exist within the BPMN (Figure 2.6).

Figure 2.6: BPMN gateways (Havey 2005)

There are also three types of connecting objects (Figure 2.7), namely: sequence flow, message flow and association (White 2004b). Sequence flow is represented by a solid line arrow and a solid arrowhead and it shows the sequence in which activities will be carried out. Message flow is represented by a dashed line arrow and an arrowhead which is open. Message flows are used to show how/when messages are sent between participants of a particular process. An association is indicated by a dotted line arrow and a line arrowhead and is used to show artifacts within the process model.

Sequence Flow	⟶
Message Flow	○----------▷
Association	·················▷

Figure 2.7: BPMN connecting objects (Havey 2005)

Actors are represented by means of swim lanes (Ottensooser *et al.* 2012). Two types of swim lanes (Figure 2.8) exist, namely a pool and a lane (White 2004b). A pool is used to represent a single participant in the process model whereas a lane is used to represent activities relating to different functions within a pool. These activities can also represent sub-processes and are linked by sequence flows (Grossmann *et al.* 2008). Message flows are used to indicate communication between participants as sequence flows are not allowed to cross boundaries. Sequence flows also show the flow of activities and not the flow of communication.

Pool	Name
Lane	Name Name / Name

Figure 2.8: BPMN swim lanes (Havey 2005)

Three artifacts can be used in a BP model to add extra information to a model (White 2004b), namely, a data object, group and annotation. An example of a BP model of an insurance claims process using BPMN is shown in Figure 2.9. The BP model starts off by receiving a claim, examining it and then splitting it into three different paths and it ends off by the claim being either accepted or rejected. Different BPMN objects are used in this diagram including basic start and end events, a message event, a timer, exclusive OR gateways and tasks.
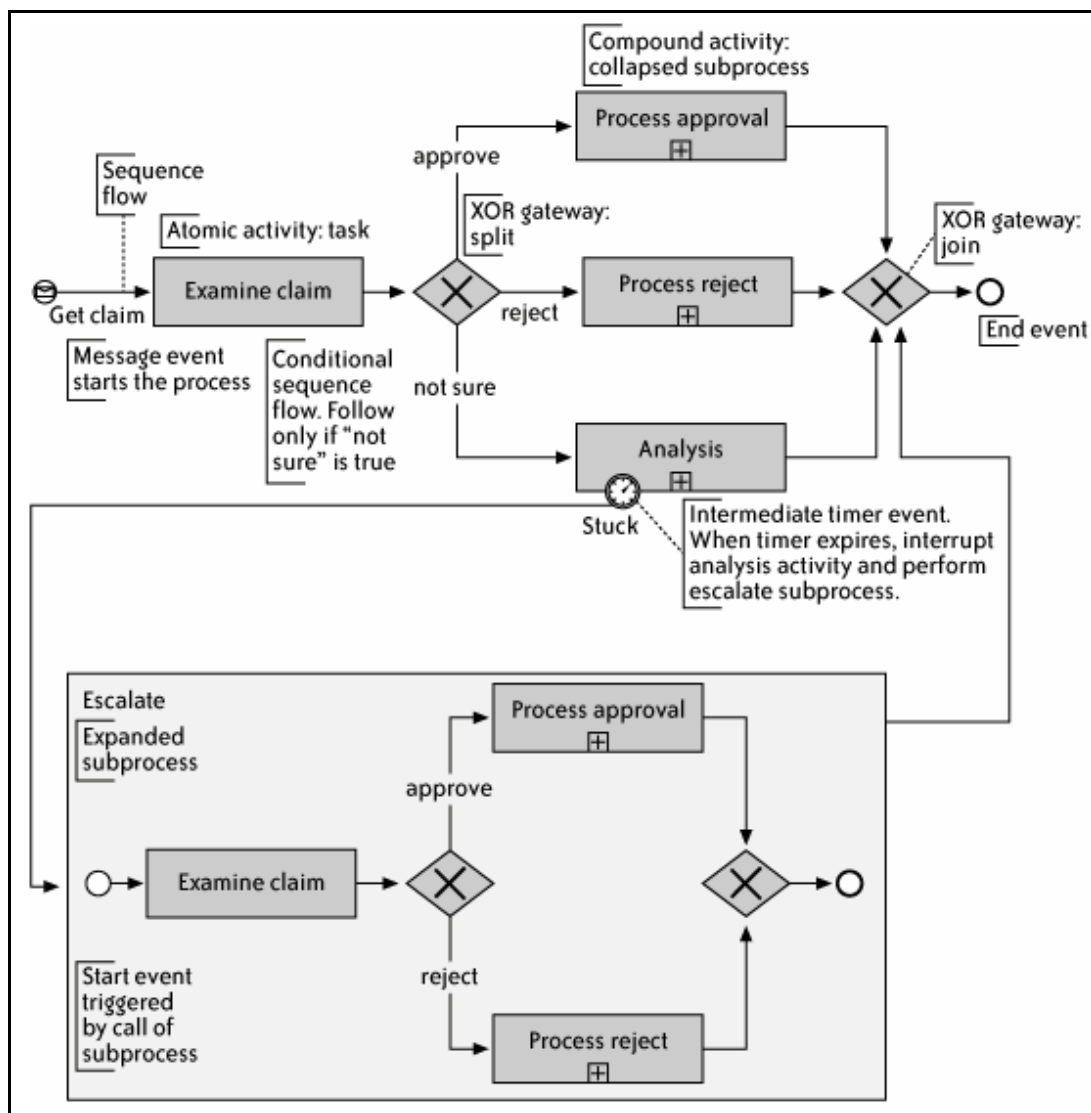
Figure 2.9: Example of an insurance claims business process model (Havey 2005)

A modelling tool refers to an application that is used to build a model, maintain the model and distribute the model whereas a modelling language refers to the grammar within the modelling technique (Sedera *et al.* 2004; Bandara *et al.* 2005). Several software solutions are available which act as reference guides to BPM where users can look up notations and rules of BPM. These solutions however do not allow users to draw BP models but to merely look up information about BPM notations and rules, similar to a dictionary. The top BPM software packages include EA, Microsoft Visio, IBM Whebsphere, AccuProcess Modeller, UModel and Bizagi Process Modeller.

EA is an enterprise-wide BPM solution which caters for the entire lifecycle of the BP including modelling, visualising, testing, analysing and maintaining processes, systems and

software (Sparx Systems 2013b). EA is a popular software solution that allows for the designing of software, BPM, creating of software and general modelling (Sparx Systems 2013a). More than 300 000 licences for EA have been sold globally and it has become the favoured modelling tool for consultants, software developers and analysts in 130 countries (Sparx Systems 2013a).

IBM WebSphere is a middleware software solution created for a Service Orientated Architecture (SOA) environment that enables interconnected BPs and the delivery of application infrastructures for any business situation (IBM 2013). Microsoft Visio allows for the easy construction of diagrams including IT networks, BP models, organisational charts, flowcharts and floor plans (Microsoft 2013). AccuProcess Modeller is a BPM software tool that enables users to document, design, improve and simulate BPs (AccuProcess 2013). UModel enables users to create stand-alone BP models or to add business rules to developmental projects (ALTOVA 2013). Bizagi Process Modeller is a freeware BPM software tool that can be used to create BP models (Bizagi 2013). Bizagi also has "BPM Suite", which is not freeware and allows users to document the automation of BPs. Tools for CBPM have been developed and can be used by stakeholders to collaborate remotely. An example of such a tool is SAP Gravity, which uses Google Wave, and allows stakeholders to collaborate via the web whilst documenting process models (Poppe *et al.* 2011). Figure 2.10 shows an example of the SAP Gravity tool.
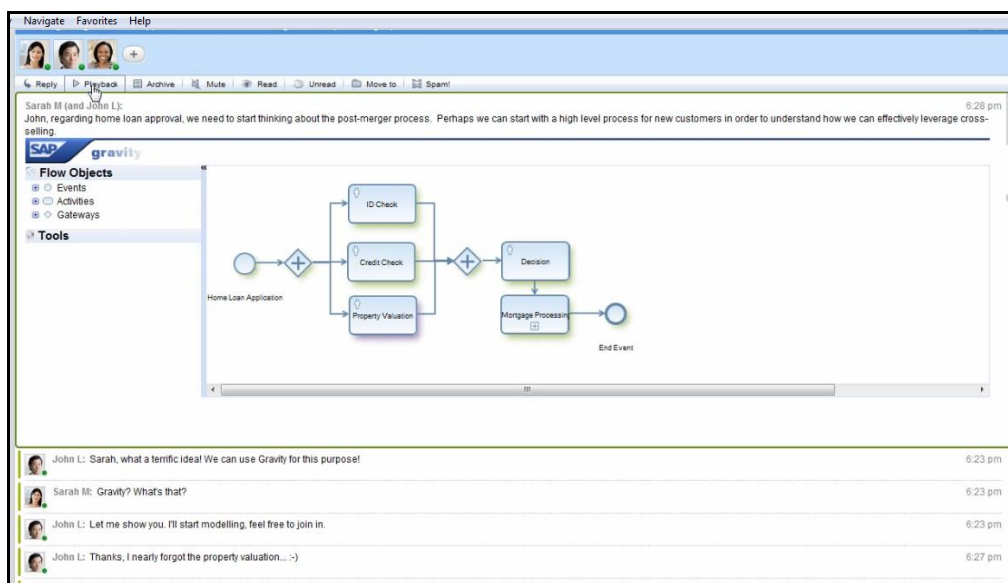
Figure 2.10: Example of SAP Gravity (Dreiling 2009)

2.4. Benefits and Challenges of BPM

BPM should be carried out before organisations start process improvements or engage in process management initiatives (Indulska *et al.* 2009a). A study was carried out by Indulska *et al.* (2009a) in which they aimed to investigate and identify what the main benefits of BPM are. The population consisted of practitioners, BPM software vendors and academics. The results varied greatly between practitioners and academics. Indulska *et al.* (2009a) believe the main reason for this is because practitioners have hands-on experience with BPM and use it in business and know what the realistic benefits to organisations are. Academics identified benefits that must still be experienced in organisations. Academics provide new knowledge and approaches to BP models in the field of BPM. Several of the benefits identified by the practitioners are intangible benefits which make it difficult to initially convince top management for their support and permission to carry out BPM activities, for example, improved visualisation and transparency.

Organisational benefits from BPM are improved focus, learning and aligning operations with the organisation's strategy (Indulska *et al.* 2009a). Managerial benefits from BPM are enjoyed by management and include the fulfilment of better decisions and good planning. Operational benefits from BPM relate to the improvement of customer service, process quality and productivity. AccuProcess (2009) also states that BPM improves operational efficiencies. IT Infrastructure benefits from BPM relate to the reduction of implementation time and costs (Indulska *et al.* 2009a). The majority of the benefits of BPM lie in the organisational and managerial dimensions. (Indulska, *et al.* 2009a).

Process improvement is the ability to enhance BPs, whereas matters relating to the identification, modelling or definition of acceptable levels of abstraction of processes is known as process performance measurement (Indulska, *et al.* 2009a). Understanding is the term used to describe an enhanced and steady understanding of processes. The communication benefit refers to the enhancement of communicating BPs between diverse stakeholder groups. The ability to enable or provision process automation, enactment or execution based on the models is known as model-driven process execution. Improving the function of modelling processes in order to analyse the models to identify problems or to make processes more efficient is known as process analysis.

Knowledge management refers to the function that supports identification, capturing and management of the knowledge pertaining to the organisation. A model library can be used in order to re-use previously created processes which proved effective. Process simulations can be run to enhance the ability to forecast how the current or a redesigned process will work and the implications thereof. The support of business change management activities, their results or the impact thereof is known as the change management benefit. Effective and efficient BPM leads to successful BPM projects (Bandara, *et al.* (2005). Havey (2005) has also identified several benefits of BPM which include:

- Formalising current processing and being able to spot needed improvements as BPM forces businesses to think through the existing processes (process performance measurement);

- Facilitating automated and efficient process flow as there is less downtime when BPM software drives the processes;

- Being able to increase and improve productivity while decreasing employee head count due to correct modelling of processes; and

- BPM also allows people to solve hard problems and simplifies regulations and compliance issues.

The benefits of BPM identified in literature have been collated and summarised according to two categories, modelling-related or project-specific (Table 2.1). Modelling-related factors relate specifically to the BPM activity and project-specific factors are factors that relate to most Information System (IS) projects.

Table 2.1: Benefits of BPM

Type	Benefit	Reference
Modelling-related	Process improvement	Havey (2005)
	Process performance measurement	Indulska *et al.* (2009a)
	Understanding of the processes	Indulska *et al.* (2009a)
	Communication	
	Model-driven process execution	
Project-specific	Improve focus	Indulska *et al.* (2009a)
	Improve learning	
	Better decisions	
	Good planning	
	Improved customer service	
	Reduced costs	
	Reduced implementation times	
	Process analysis	
	Knowledge management	
	Model re-use (model library)	
	Process simulation	
	Change management	
	Efficient and effective BPM project	Bandara *et al.* (2005)
	Improved productivity	Havey (2005) Indulska *et al.* (2009a)
	Facilitates automated and efficient process flow	Havey (2005)
	Decreased employee head count	
	Allows people to solve hard problems	
	Simplifies regulations and compliance issues	
	Aligns operations with business strategy	AccuProcess (2009) Indulska *et al.* (2009a)
	Improves operational efficiencies	AccuProcess (2009)

Whilst there are several potential benefits to BPM (Table 2.1), some challenges have also been reported. A study to identify the limitations and future challenges of BPM was carried out by Indulska *et al.* (2009b). In this study Indulska *et al.* (2009b) aimed to identify the challenges relating to BPM and what the perceived challenges of BPM will be in half a decade's time (2014 – 2015).

From the results of the study (Indulska *et al.* 2009b) it was evident that the stakeholder groups differed greatly. Practitioners indicated that *Standardisation* is the biggest current challenge in BPM, whilst vendors indicated that *Model-driven process execution* is the biggest current challenge. Academics, on the other hand, indicated that *Service orientation* is the biggest current challenge. Standardisation refers to issues that relate to the standardisation of tools, methodologies and notations used for modelling. In total, 36% of the major current challenges identified relate to the methodological aspects pertaining to BPM. From the original results, they concluded that vendors and practitioners focus on problems surrounding the purpose and implementation of BPM, whilst academics focus on problems associated with the development and testing of artifacts.

Additional future challenges that were identified by practitioners but not by academics include: the value of BPM, process architecture, expectations management, adoption and training. The value of BPM is research focussing on the benefits and costs associated with BPM. Expectations management is research focussing on the expectations, preconception, disconfirmation and confirmation of stakeholders in BPM. Training is research that focusses on various approaches to building BPM expertise and the effects of such skill on the quality of BPM. Process architecture is research that investigates the development, structuring and use of architectural models in guiding BPM. Adoption is issues relating to determinants of organisations and individuals adopting and continuing to use BPM. Lastly, modelling methodology refers to instructions that guide the modelling process. Aspects of the methodology include the method of modelling, quality assurance, naming conventions and standards (Sedera *et al.* 2004; Bandara *et al.* 2005; Indulska *et al.* 2009b).

The challenges identified by Indulska *et al.* (2009b) can be grouped according to modelling-related and project-specific challenges (Table 2.2). The top five BPM challenges are: standardisation, model management, modelling level of detail, business-IT-alignment and service orientation. These are shown in a bold typeface in Table 2.2.

Table 2.2*:* **BPM challenges (Indulska** *et al.* **2009b)**

Type	Challenge	Reference
Modelling-related	**Standardisation**	Indulska *et al.* (2009b)
	Model management	
	Modelling level of detail	
	BPM expertise	
	Ease of use	
	Collaborative modelling	
	Methodology	
	Process architecture	
Project-specific	**Business-IT-alignment**	
	Service orientation	
	Expectations management	
	Value of process modelling	
	Model-driven process execution	
	Training	
	Adoption	
	Buy-in	
	Governance	
	Process orientation	

The focus of this study is on the activity of drawing models (modelling-related) and not on project-specific or management-related issues. Therefore the five benefits and challenges (Table 2.3) which specifically related to the activity of modelling were extracted from Tables 2.1 and 2.2. The five benefits were those identified by Indulska *et al.* (2009a), namely process improvement, process performance measurement, understanding of the process, communication and model-driven process execution.

The modelling related BPM challenges identified were the top five reported by Indulska *et al.* (2009b), namely standardisation, model management, modelling level of detail, BPM

expertise and ease of use of BPM tools. Collaborative modelling will be explored in more detail in Chapter 3.

Table 2.3: Modelling-related benefits and challenges of BPM

Benefit/Challenge	Reference
Benefit	
Process improvement	Havey (2005)
Process performance measurement	Indulska *et al.* (2009a)
Understanding of the process	Indulska *et al.* (2009a)
Communication	
Model-driven process execution	

⬆ *Impacts*

Challenge	
Standardisation	
Model management	
Modelling level of detail	Indulska *et al.* (2009b)
BPM expertise	
Ease of use	
Collaborative modelling	

2.5. Critical Success Factors (CSFs) and Success Measures of BPM

Bandara *et al.* (2005) derived a model in which they documented success factors as well as success measures for process modelling. Successful BP models are important since they can lead to efficient and effective projects (Bandara *et al.* 2005). An efficient process modelling project is one that is completed within the outlined time and budget constraints. Five project specific CSFs for BPM have been identified (Figure 2.11) and these are:

- Stakeholder participation / User Participation (Sedera *et al.* 2004; Bandara *et al.* 2005);
- Management support (Sedera *et al.* 2004; Bandara *et al.* 2005);

- Information resources / Communication (Sedera *et al.* 2004; Bandara *et al.* 2005);

- Project management (Sedera *et al.* 2004; Bandara *et al.* 2005); and

- BPM (modeller) expertise (Sedera *et al.* 2004; Bandara *et al.* 2005) which was also identified as a challenge by Indulska *et al.* (2009b).

Stakeholder participation refers to the participation from any individuals who have a role in the BP being modelled, these can also be model users (Sedera *et al.* 2004; Bandara *et al.* 2005). Management support refers to the commitment (to the modelling project) that has been received from top management, therefore sometimes referred to as management participation. Communication (also referred to as Information resources) refers to the information portrayed, derived from team members and the breakdown of the response received from the users. Project management includes the formal information such as the scope of the project, important dates, milestones and plans to be followed which is similar to the communication CSF that was identified by (Sedera *et al.* 2004). BPM expertise refers to the work experience that the modeller has and an ideal experience includes business, company-specific, product, technical, project management and communication knowledge.

The three additional CSFs for BPM, identified by Bandara *et al.* (2005) not identified by Sedera *et al.* (2004) are team structure, leadership and user competence. These are shaded in green in Table 2.4. Team structure is the correct combination of stakeholders related to the processes being modelled successfully (Bandara *et al.* 2005). Leadership refers to someone who has the power to drive the project in a specific direction by outlining goals and making changes. User competence refers to matters that pertain to that amount of knowledge that the users of the BP models have about the modelled domain and procedures. The three modelling-related CSFs (Figure 2.11) are modelling methodology, modelling language and modelling tool (Sedera *et al.* 2004; Bandara *et al.* 2005). The CSFs identified in literature have been summarised in Table 2.4.
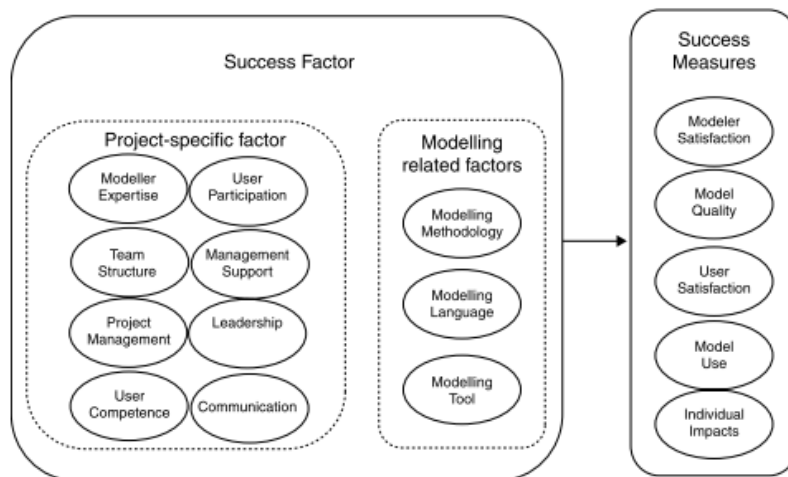
Figure 2.11: A priori model of BPM success factors and measures (Bandara *et al.* 2005)

Table 2.4: CSFs for BPM

Type of factors	CSF	Sedera *et al.* (2004)	Bandara *et al.* (2005)
Project-specific	Stakeholder (user) participation	X	X
	Management support	X	X
	Communication (information resources)	X	X
	Project management	X	X
	Modeller expertise	X	X
	Team structure		X
	Leadership		X
	User competence		X
Modelling-related	Modelling methodology	X	X
	Modelling language	X	X
	Modelling tool	X	X

Team structure, leadership and user competence are the additional CSFs that have been identified (Table 2.4). The success measures that are relevant to the context of this study, since they relate to modelling-specific factors, have been identified and shown in Table 2.5. Individual impacts has not been included in the list as it is not modelling specific and the

focus of this study is on BPM. Efficiency and effectiveness (shaded in green) have been added to the list as they are applicable to a modelling-specific study (Sedera *et al.* 2004; Bandara *et al.* 2005). Three modelling-related CSFs are also included in Table 2.5.

Table 2.5: CSFs and success measures for BPM

CSF/Success measure	Reference
CSF	
Modelling methodology	Sedera *et al.* (2004)
Modelling language	Bandara *et al.* (2005)
Modelling tool	
Success measure	
Modeller satisfaction	
Model quality	
User satisfaction	Sedera *et al.* (2004)
Model use	Bandara *et al.* (2005)
Efficiency	
Effectiveness	

2.6. Framework for BPM

An initial framework for BPM is proposed based on the selected benefits, challenges and success measures (Figure 2.12). All of these factors are modelling-related factors and therefore relevant for this study. The framework can assist organisations in the planning phases for BPM and with making decisions regarding BPM in their organisation. In particular the potential benefits of BPM should be examined before embarking on a BPM project. Organisations also need to take the challenges of BPM into consideration in order for them to be prepared for any risks and challenges that could occur. Lastly, organisations need to identify appropriate measures in order to measure the success of the BP models created by modellers. Modelling methodology and modelling language are two success measures but they do not form part of the scope of this study.

Before IT projects are started, the challenges need to be identified and justified and the expected returns from the project need to be clearly identified and documented so that top

management can approve the project (Schwalbe 2013). It is important that the expected benefits outweigh the costs (risks and challenges) of the project. Organisations also need to take the CSFs into consideration so that they can put these factors into place before the project commences, in order to increase the chances of success. Lastly, organisations need a way in which they will measure the Return On Investment (ROI) once the project has been completed. The success measures for BPM can be used to measure the ROI from CBPM projects.

BPM Planning Elements

Identify Benefits of BPM

Process improvement
Process performance measurement
Understanding of the process
Communication
Model-driven process execution

Affects

Investigate Challenges of BPM

Standardisation
Model management
Modelling level of detail
BPM expertise
Ease of use

Affects

Analyse CSFs

BPM TOOL

Evaluates

Consider Success Measures for BPM

Modeller satisfaction
Model quality
User satisfaction
Model use
Efficiency
Effectiveness

Figure 2.12: Proposed framework for BPM planning

39

2.7. Conclusion

Process improvement, process performance measurement, understanding of the process, communication and model-driven process execution are the top five perceived benefits (Table 2.3) of BPM identified in literature that are modelling-related. Only these will be the focus of this study. Whilst there are several benefits of BPM there are also many challenges. Standardisation, model management, modelling level of detail, BPM expertise and ease of are the top modelling-related challenges (Table 2.3) which forms part of the proposed framework (Figure 2.12).

Sedera *et al.* (2004) and Bandara *et al.* (2005) documented several CSFs for BPM including modelling methodology, modelling language and modelling tool (Table 2.4). The success measures for BPM were also documented (Figure 2.11) however, not all of the success measures are relevant to this study, therefore only the modelling-related measures (Table 2.5) are included in the framework. These include: modeller satisfaction, model quality, user satisfaction, model use, efficiency and effectiveness.

Therefore the first two research objectives "*Identify the benefits and challenges of CBPM*" and "*Identify the critical success factors and success measures of CBPM*" have partially been met. The research questions of this study that have partly been answered in this chapter are:

RQ_1: *"What are the benefits and challenges of CBPM?"*
RQ_2: *"What are the critical success factors and success measure for CBPM?"*

This chapter aimed at partially addressing Activity 1 of DSR, "Identify problem and motivate" (Section 1.10.2). Activity 1 will be completely addressed in Chapter 3. In order to fully answer these two research questions, Chapter 3 focusses on the collaboration aspect of the problem in this study which is CBPM. The identified benefits, challenges, CSFs and measures of BPM will be validated by means of a survey (Chapter 3) together with the additional aspects which need to be considered with CBPM. The first two research questions will therefore be completely answered in Chapter 3.

Chapter 3
Problem Identification of Collaborative Business Process Modelling

3.1. Introduction

Chapter 2 reported on the importance of BPM in an organisation and the benefits, challenges CSFs and measures for BPM. BPM is however an activity that should be carried out in a collaborative environment. In this study a collaborative environment is an environment in which multiple modellers are present in a single location and work together on a process model. BPM carried out in a collaborative environment will be referred to as CBPM. The main research problem of this study is *"Modellers experience difficulties conducting collaborative business process modelling activities in a co-located environment"*.

Computer supported cooperative work is investigated briefly to provide a better understanding of collaborative software (Section 3.2). In order to validate the research problem and to investigate the problems of CBPM, existing approaches and solutions are explored (Section 3.3). The CBPM software will be investigated to determine if there is a suitable CBPM software solution on the market that caters for co-located CBPM using touch technologies. EA is described as a BPM software solution that caters for collaboration as users can share models by exporting and importing them into their respective process model. EA will therefore be evaluated to further explore the problem of CBPM.

In order to validate the main research problem, two investigations of CBPM had to be undertaken. A pilot study involving both students and industry participants who used EA to model a BP diagram was carried out (Section 3.4). The participants then had to complete a post-test questionnaire to report on their experiences. This initial study of CBPM will be referred to as the pilot study in later chapters. In order to empirically validate the theory and the pilot study, a survey regarding CBPM was sent out to modellers at consulting

organisations all over South Africa (Section 3.5). This chapter will complete Activity 1 of DSR "Identify problem and motivate" (Section 1.10.2). The first two research questions will therefore be answered fully in this chapter and these are:

RQ$_1$: "What are the benefits and challenges of CBPM?"
RQ$_2$: "What are the critical success factors and success measure for CBPM?"

An updated framework will be proposed which will include the benefits of CBPM, challenges of CBPM, validated success measures and the CSFs for CBPM (Section 3.6). The two research objectives "*Identify the benefits and challenges of CBPM*" and "*Identify the critical success factors and success measures of CBPM*" will thus be fully met at the end of this chapter and several conclusions will be made (Section 3.7). The chapter layout is shown in Figure 3.1 which includes the research objectives and deliverables.
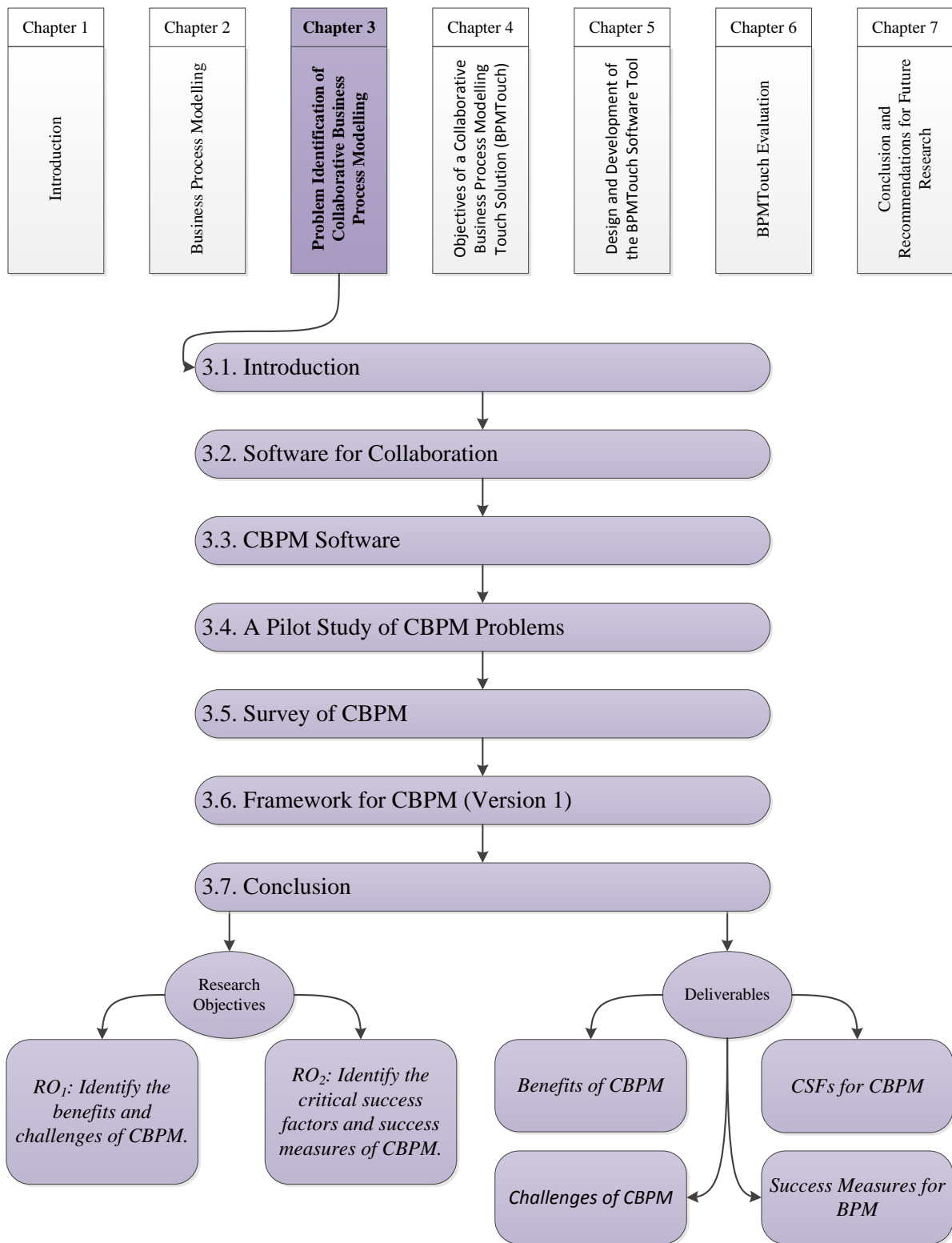
Figure 3.1: Chapter 3 layout and deliverables

3.2. Software for Collaboration

Computer Supported Cooperative Work (CSCW) is a field of research in which technology is used by multiple people simultaneously in a collaborative environment (Rama and Bishop 2006). CSCW is comprised of two dimensions, namely space and time. *Groupware* enables multiple individuals to work on a project simultaneously (Rama and Bishop 2006). Groupware, also referred to as collaborative software, revolves around the group whereas the focus of single user systems revolves around an individual. It caters for multiple points of view, as well as expertise. The goal of groupware is to save time and money in group environments. Groupware systems are designed around the users and therefore, it is crucial to have a clear understanding of how the systems will be used. Groupware refers to the technologies that aid individuals to work in a group environment whereas CSCW refers to the research area (Grudin 1994). Ellis, Gibbs and Rein (1991) define groupware as a computer system that provides support to a group of people who share a goal and deliver an interface to a common workspace. Groupware can either be *real-time groupware*, in which simultaneous user interaction is possible or *non-real-time groupware*.

In order to support interaction in a group setting, three factors need to be taken into consideration, namely coordination, collaboration and communication (Denise 2010). Coordination within a group of participants increases the effectiveness of the communication and collaboration factors. Coordination limits group conflict and repetition of actions and work within a group. It also involves notifying each part of the group how to act and when the right time would be to act.

Effective collaboration involves information sharing between and amongst group participants (Ellis *et al.* 1991). It is important that group participants receive notifications of other participants' activities if it is deemed necessary as well as up-to-date displays of information. Denise (2010) however, documents that collaboration is the use of information, not the exchange of information. Communication however, refers to how information is exchanged in the organisation and how people understand each other. Both communication and collaboration are important to group activities (Ellis *et al.* 1991).

Face-to-face interaction in a co-located environment can be very valuable when conducting complex tasks (Isenberg *et al.* 2010). Isenberg *et al.* (2010) investigated how individuals

communicate in a team environment around a table top system and concluded that the visualisation was deemed most efficient when all participants had control over their own/different parts of the data being visualised. Multi-touch surfaces in co-located environments promote the sharing of tools, resources and information in a face-to-face setting. The technologies used for co-located collaboration have several constraints, as well as benefits of their own (Hornecker *et al.* 2008). Tools such as e-mail, cellular phones and blogging all form part of CSCW, with the goal of giving individuals a means of communicating and collaborating to suit their needs (Nardi, Schiano and Gumbrecht 2004; Shah 2010).

3.3.   CBPM Software

BPM is considered a collaborative activity since it involves various stakeholders within the organisation and across organisations (Poppe *et al.* 2011). Process modelling experts need to consult with the appropriate stakeholders in order to correctly model the required BPs. Collaboration is grouped into *remote (dispersed) collaboration* or *co-located collaboration* (Twidale and Nichols 1996; Shah 2010). Remote collaboration refers to people working together synchronously or asynchronously while they are in different locations. Co-located collaboration refers to people working together synchronously or asynchronously in the same location (Twidale and Nichols 1996; Shah 2010; Oxford University Press 2013b). If individuals share information or work together at the same time it is known as *synchronous* sharing (Twidale and Nichols 1996; Shah 2010). If individuals share information at different times, it is referred to as *asynchronous* sharing. Figure 3.2 shows systems and methods that can be used for collaboration, for example, Google Docs can be used for remote synchronous collaboration and Post-it notes can be used for co-located asynchronous collaboration.

Face-to-face meeting   TeamSearch   **Co-located**   Post-it notes

CoSearch   I-Spy

Video games   OPAC   AntWorld

Synchronous ———————————————————— **Asynchronous**

Phone   Second Life   Ariadne SearchTogether Coagmento   Amazon Netflix

Adobe Connect
Online gaming   Google Docs   Snail mail
IM   Wikipedia   Email

Remote
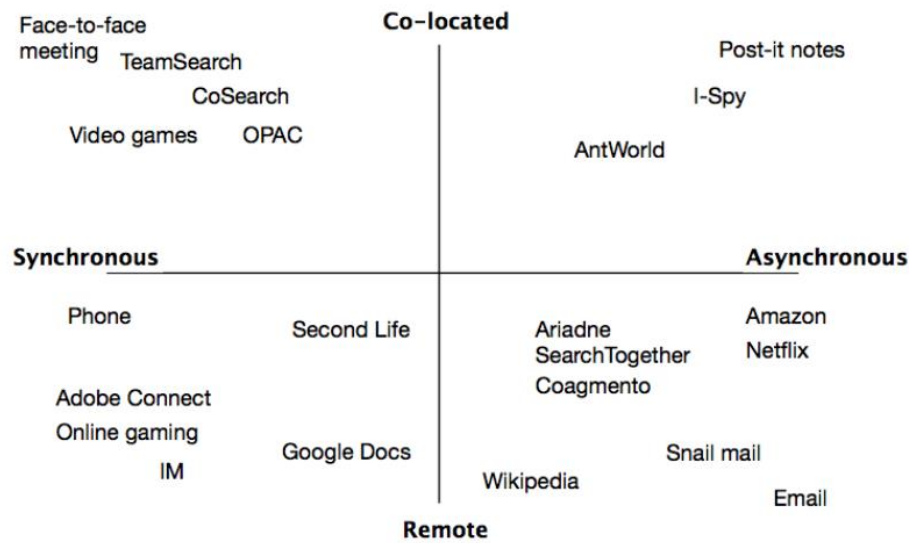
Figure 3.2: Classical model of collaborative systems and methods (Twidale and Nichols 1996)

Another type of CBPM refers to the collaboration between the various stakeholders in the modelling process. Barjis (2009) developed a modelling approach called Collaborative, Participative, Interactive modelling (CPI modelling) that incorporates collaboration, participation and interaction of stakeholders in the modelling process. The main aim of CPI modelling is to create one model in a collaborative environment that is validated by the stakeholders (Barjis 2011). Creating one model and sharing input is therefore a CSF of CBPM.

The benefits of CBPM (from CPI modelling) are more accurate models, faster modelling and direct feedback from all of the participants (Barjis 2011). As the modellers interact closely, the need to make assumptions decreases and the overall quality of input from each modeller is improved. Stakeholders that are present in the sessions also have a better understanding of the processes (Barjis 2009), as the process owners are present, which will lead to more enthusiasm within the organisation and more support from management (Barjis 2011). By interacting this way, faults will be identified sooner and minimal sessions will be necessary which will result in lower cost and time resources. The sessions also result in shared ownership of the processes and more confidence amongst the process users (Barjis 2009).

The study of Barjis (2011) also identified some challenges of CBPM. BPs could be spread over multiple organisational units and numerous stakeholders are involved which can lead to BPM project delay. The process owners may have different perceptions of how to model the process from those of the modeller.

46

Process owners also have domain knowledge and experience with their processes and therefore it would be ideal if they are present when the processes are modelled. The *modellers* do not always understand what is required and therefore have to do many iterations of process modelling before the ideal model is created.

If process owners could be present in the modelling session along with other relevant stakeholders, the process can be modelled in minimal iterations but time management might be a problem (Barjis 2011). Dollmann *et al.* (2011) agree that several stakeholders should be present and states that the involvement and collaboration of different participants is a precondition for successful CBPM. On the other hand, only relevant stakeholders should be present as extra stakeholders can make the modelling process time consuming. It is evident that stakeholder presence (user participation) in modelling (Lee *et al.* 2000; Barjis 2011; Poppe *et al.* 2011) and time management (Barjis 2011) are CSFs for CBPM. Other CSFs for CBPM identified by Barjis (2011) are modellers giving different inputs and interpretations of the processes, drawing only one diagram and sharing input to that diagram, and modelling tool. From the literature, it is evident that the following participants should be present in a CBPM environment (Lee *et al.* 2000; Barjis 2011; Poppe *et al.* 2011):

- Process owners;
- Relevant stakeholders;
- Business analyst;
- Session facilitator;
- Modelling expert; and
- Observers.

The CPI modelling framework consists of the collaboration (expert aspect), participation (user aspect) and interaction (tool aspect) aspects (Barjis 2011). The interaction aspect emphasizes the need for tools that allow the creation of BP models in collaborative environments. Therefore, BPM tool is a CSF for CBPM. In the case studies conducted with the CPI modelling, an interactive whiteboard was used to conduct the BPM activities on. CPI modelling is most successful in a co-located environment with synchronous interaction. CPI modelling is, however, only in a conception phase and more research is required (Barjis 2011).

Collaborative Distributive Scenario and Process Analyzer (CoID SPA) is a proof-of-concept tool that is web-based, which was developed to support both dispersed and co-located settings in which participants can collaboratively create BP models (Lee *et al.* 2000). During the evaluation of this tool, various limitations were identified including the fact that entire records in tables are locked when a participant makes an update and therefore other participants cannot access that record which indicates a lack of flexibility and shows that graphical functionality needs to be improved.

Dollmann *et al.* (2011) presented a concept for CBPM as well as an implemented prototype, the CoMoMod tool. The prototype was created to solve some of the problems in managing BPs in virtual organisations which tend to change constantly throughout their life cycle. The key features of the CoMoMod tool are; concurrent work, integrated communication, different modelling languages, defined technical terms and merging of model parts. CoMoMod supports the concurrent work of dispersed modellers on one process model indicating that modellers from dispersed organisations can work on a single model synchronously.

The CoMoMod tool allows for integrated communication so that modellers working together can comment on the work of their peer modellers. The tool caters for different modelling languages so that each modeller can model in his/her preferred and understood modelling language. CoMoMod supports the usage of a predefined vocabulary and technical terms, which are used for labelling the elements used in a model. Lastly, CoMoMod also enables the integration of process model parts which have been modelled in different organisations. The models are exchanged in an XML-based format between the modellers via peer-to-peer connections. Each modeller then works on a translation of the model (in his/her language) which is executed on each partner's local instance of CoMoMod. If the model is not adequately converted into a specific modelling language, modellers can manually convert the model into the desired modelling language.

A Modeller can convert the Petri Net into an EPC model by making use of the conversion function after which he/she can analyse the partner's model in a notation that he/she is comfortable with (Figure 3.3). Figure 3.3 shows a modeller's screen with two different models. In the left window, modeller one used EPC to draw the process model and is connected to modeller two who has a model modelled in Petri Nets. Modeller one can see modeller two's model which is similar to his/her own model.

The modellers can then communicate by making use of the chat functionality and work collaboratively on the process. All of the changes made by one modeller will be presented to the other modeller in their desired BPM languages. The tool has several limitations as it only caters for EPC diagrams and Petri Nets and it has not been tested in real-life scenarios indicating that it needs further evaluation to determine any side-effects (intended and non-intended) of the CoMoMod tool.
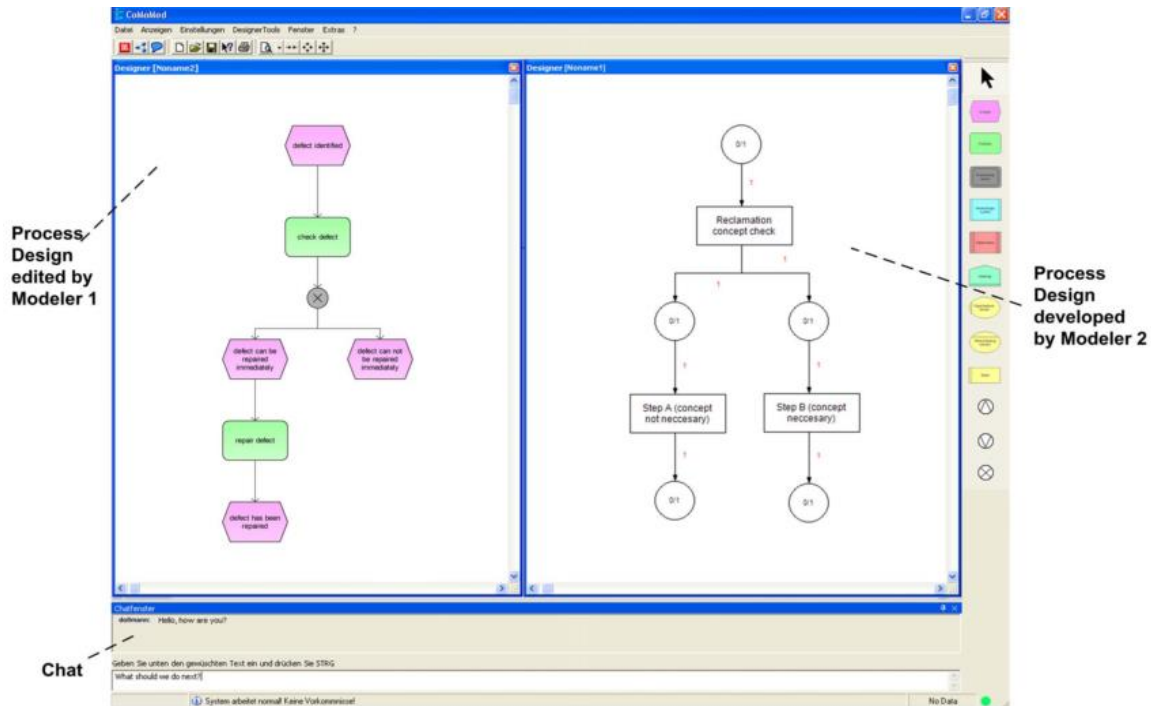
Figure 3.3: A screenshot of the CoMoMod tool (Dollmann *et al.* 2011)

Another tool for CBPM is discussed by Rittgen (2008) and is known as Collaborative Modelling Architecture (COMA) and was tested in two case studies. The tool provides various functionalities which make it unique and these are the ability to propose, challenge, support and accept. A proposal refers to a suggestion that a current version of the model needs to be revised. This means that a modeller can post his/her model on the group. A challenge refers to an undesirable valuation of the new proposal and it must be accompanied by a justification for the challenge and comments to aid in the improvement of the proposed model. A support refers to a positive valuation of the new proposal and it may be accompanied by a comment for the rationale of the decision. A support can be given by any member of the modelling team after revising the new proposal. A proposal can then be accepted based on either majority or seniority. If a proposal is based on majority it depends

on the number of challenges and supports received. If a proposal is based on seniority, the facilitator makes the decision of whether to accept the model or not.

The COMA tool has three panes (Figure 3.4), where the top pane shows the current version of the model that the group is working on and it cannot be edited (Rittgen 2008). The bottom left pane is referred to as the editor pane and each modeller can use this pane to work on his/her model individually. The bottom right pane is the proposal pane in which a modeller can load a proposal made by other modellers or by the current modeller. The COMA tool uses UML as a basis; it is Windows based, implemented in Visual C++ and uses a UML Pad. The COMA tool however, only caters for UML notation, it can only run on the Windows operating system and does not cater for touch input.
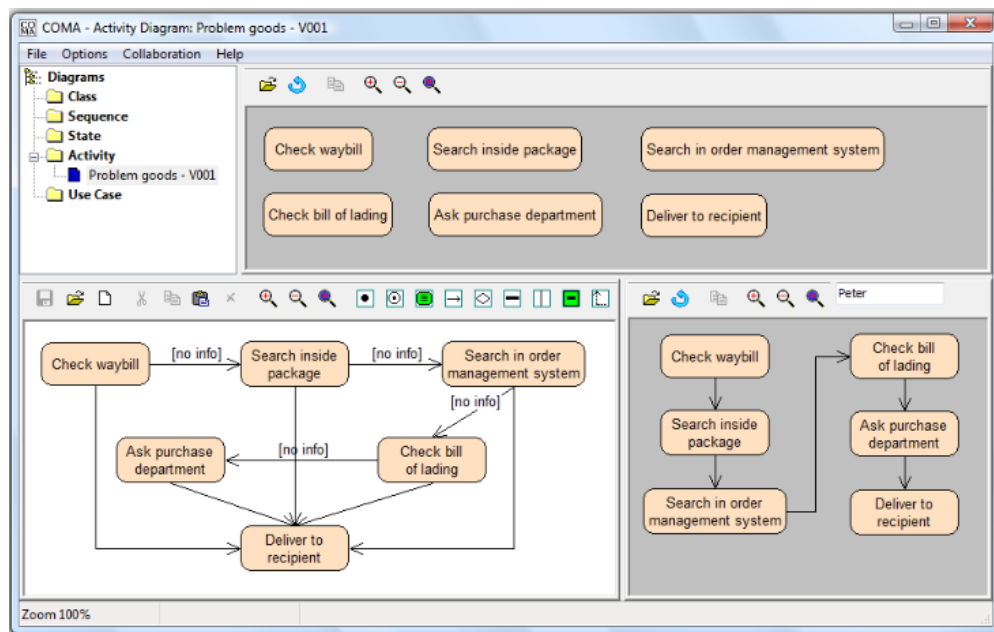
Figure 3.4: Screenshot of the COMA tool (Rittgen 2008)

All of these software tools allow users to carry out BPM in a collaborative environment, however none of them cater for touch input and easy integration of models. In CPI modelling a whiteboard was used for the process modelling and that does not cater for integration of different models. The CoID SPA BPM tool was faulty and therefore needs improvements need to be made. The CoMoMod tool allows a model to be drawn and converted to a different modelling language for a second modeller, however; it does not allow modellers to model using the popular BPMN modelling language. The COMA tool also does not allow for the use of the BPMN. Therefore, none of these tools will suffice to form part of the framework for CBPM.

3.4. A Pilot Study of CBPM Problems

As part of the problem identification, participants of a BP management course took part in a software evaluation of CBPM. The course was offered as a short one week course, by the Department of Computing Sciences at NMMU as part of the DASIK project (DASIK 2012). Approximately 20 people, including university students and industry participants, attended the course. Participants were given consent forms (Appendix C) to take part in the study and were then supplied with the purpose and instructions of the BPM activity (Appendix G). Participants were also provided with written information (Appendix D) pertaining to the evaluation and an oral explanation (Appendix E).

Participants were then provided with a scenario (Appendix H) that they had to model in small teams of two to four modellers using the modelling software EA and using the BPMN notation. The participants were instructed to model the scenario in their teams and provide the course instructor with one final model from each group. The way in which the participants interacted was not prescribed, so the participants had the option of using as many desktop PCs as was required and could collaborate in any manner they selected. Upon completion of the activity, participants were required to complete a biographical questionnaire (Appendix A) and two post-test evaluation questionnaires (Appendix I and J). The questionnaires consists of several questions that the participants had to answer by making use of a 7-point Likert scale where 1 represents *Strongly Disagree* and 7 represents *Strongly Agree*.

The results revealed that the majority of the participants experienced minimal usability problems with the EA modelling tool, were satisfied with their task time and overall model, made a minimal number of errors and understood the scenario. In all of the cases the participants worked together to draw a hand-drawn version of the model of the scenario; most of the team members participated and the team members were able to communicate with ease. Approximately 75% (n = 15) of the participants indicated that it was easier to collaborate and have a partner to conduct the process modelling tasks.

The way the model was created varied from group to group. In several cases the group members each drew their own rough model on a piece of paper and afterwards combined their models to create a final model. The team members then discussed everyone's representation of the scenario and worked together to create a final model. In other cases one person was

allocated the role of modeller and the team members then collaborated with the modeller by explaining their thoughts and ideas while the modeller constructed the model on a PC. In one case two separate PCs were used to model the process whereas in the majority of teams, only one PC was used for the modelling of the process and only one modeller modelled at a time. Approximately 75% (n = 15) of the participants indicated that they preferred collaborative modelling to individual modelling.

The participants were required to report any challenges they had with CBPM in open-ended questions. Qualitative analysis (thematic analysis) was used to identify the challenges and where possible, existing challenges were used as a priori themes. Tables 3.1 to 3.3 document the benefits, challenges and CSFs for CBPM which were derived based on the theoretical study of collaborative work and the results from the pilot study. The results of the pilot study confirmed the benefits identified in literature by Barjis (2009, 2011) namely, increased understanding amongst modellers, more accurate modelling and direct feedback from participants. Two additional benefits were also confirmed, namely, brainstorming amongst modellers (Twinning *et al.* 2005; Berry and Hamilton 2006) and learning from other modellers (Twinning *et al.* 2005). One new challenge was identified; sharing ideas, opinions and different points of view between modellers but this is related to brainstorming and learning. The benefits of CBPM which are shaded light green in Table 3.1 are added to the benefits of BPM to form a superset of CBPM benefits which will be empirically validated in the survey of CBPM in organisations (Section 3.5).

Table 3.1: Benefits of CBPM

Benefit of CBPM	Reference
Increased understanding of processes amongst modellers	Barjis (2009)
Shared ownership of processes	
Confidence amongst process users	Barjis (2011)
Accurate modelling as processes owners and more modellers are present	
Brainstorming amongst modellers	Pilot study ($f^1 = 1$) Twinning *et al.* (2004) Berry and Hamilton (2006)
Sharing ideas, opinions and different points of view between modellers	Pilot Study ($f = 11$)
Learning from other modellers	Pilot Study ($f = 1$) Twinning *et al.* (2004)
Fewer assumptions are made	Barjis (2011)
Direct feedback from participants	

The pilot study confirmed that having different interpretations of the process from each modeller and time management (people aspect) are challenges of CBPM. Three additional challenges were also identified: difficulties integrating and combining different versions of models and model changes; time management (technical aspect) and technology constraints with desktop PCs. The challenges of CPBM (Table 3.2) shaded in light green will be added to the challenges of BPM and used in the industry survey of CBPM (Section 3.5).

---

[1] Frequency (f) is the number of participants whose responses formed part of a particular theme in thematic analysis.

53

Table 3.2: Challenges of CBPM

Challenges of CBPM	Reference
Difficulties of integrating and combining different versions of models and model changes	Pilot Study (f = 4)
Time management – technical aspect	Pilot Study (f = 1)
Technology constraints with Desktop PCs	Pilot Study (f = 2)
Having different interpretations of the process from each modeller	Barjis (2011)
Time management – people aspect	
Multiple organisational units may form part of a process	
Modellers do not always understand what is required	

The pilot study confirmed user participation, time resources, modellers giving different inputs and interpretations of the processes, and drawing only one diagram and sharing input to that diagram as CSFs for CBPM (Table 3.3).

Table 3.3: CSFs of CBPM

CSFs of CBPM	Reference
User participation	Pilot Study (f = 14)
	Lee *et al.* (2000)
	Barjis (2011)
	Poppe *et al.* (2011)
Time resources	Pilot Study (f = 4)
	Barjis (2011)
Modellers giving different inputs and interpretations of the processes	Pilot Study (f = 8)
	Barjis (2011)
Drawing only one diagram and sharing input to that diagram	Pilot Study (f = 1)
	Barjis (2011)
Modelling tool	Barjis (2011)

3.5. Survey of CBPM

An online survey regarding CBPM was conducted amongst industry participants to complete. This section details the approach that was taken to carry out the survey (Section 3.5.1) and the research instruments that were used to create the survey (Section 3.5.2). Forty-five participants took part in the survey and the results were analysed and documented (Section 3.5.3).

3.5.1. Research Approach

An online survey was conducted based on previous studies in the field of BPM (Harmon and Wolf 2011; Indulska *et al.* 2009a; Indulska *et al.* 2009b) and CBPM (Twinning *et al.* 2004; Berry and Hamilton 2006; Barjis 2009, 2011). The main purpose of this survey was to determine the status of BPM and CBPM in South African organisations and the perceptions of these two activities. Sections in the survey were based on theoretical studies of BPM and CBPM in order to provide additional empirical evidence of these studies and more specifically the benefits and challenges of BPM in organisations, the proposed success measures of BPM and to understand how companies perceive CBPM. The survey data was exported to a Microsoft Excel spread sheet for analysis purposes. The content validity of the questionnaire was established since all of the questions were derived from literature (Data Analysis Australia 2013) and was validated by a pilot study (Statistics.com 2013). Therefore validity and reliability of the survey was established by means of a pilot study.

The self-selection sampling method was used to select participants as it is a method that allows participants to be collected by asking them to take part in the study (Saunders, Lewis and Thornhill 2009). Several organisations were selected and asked to participate in the survey. The organisations which took part in this survey were selected based on the following criteria:

- The organisation had to have employees that conduct BPM for other companies (as consultants); and
- The participants had to have carried out BPM activities.

A cover letter (Appendix F) was sent to the organisations to obtain permission from managers to survey their employees. The link to the survey was emailed to the relevant contacts at the

various companies. All of the managers that agreed were asked to complete a BPM survey as well that consisted of basic questions relating to the organisation (Appendix S).

3.5.2. Research Instruments

The survey for CBPM consisted of ten sections (Appendix B). Section 1 of the survey, *Organisation Related (S1),* includes questions such as the size of the organisation, the industry in which the respondent works, the job title/function and business process modelling in the organisation.

Section 2 of the survey, *Business Process Modelling Tool Features (S2)*, contains four statements that the participants had to rank on a 5-point Likert scale. The statements are: the ability to store models and process in a data repository, collaborative modelling (the ability of the tool to support multi-stakeholder collaborative modelling), the ability of the tool to support multi-collaborative modelling and the ability to post models on the web so that they can be widely shared (Harmon and Wolf 2011).

The 3rd and 4th sections of the questionnaire were *The Benefits of Business Process Modelling* (S3) and *Business Process Modelling Challenges* (S4) respectively and were designed based on the studies of Indulska *et al.* (2009a, 2009b) and the framework for BPM Planning proposed in this study (Figure 2.12). The benefits of BPM listed in this section are: process improvement, understanding, communication, model-driven process execution and process performance measurement.   The BPM challenges listed in the questionnaire are: standardisation, model management, modelling level of detail, BPM expertise and ease of use (tool).

Success measures (S5) and CSFs (S8) were identified in a literature study as part of the proposed framework for BPM Planning (Figure 2.12) and are included in the survey for validation purposes. The measures are: modeller satisfaction, model quality, user satisfaction, model use, efficiency and effectiveness. The modelling tool is a CSF for BPM projects and additional CSFs for CBPM are user participation (Lee *et al.* 2000; Barjis 2011; Poppe *et al.* 2011), time resources, modellers giving different inputs and interpretations of the processes and drawing only one diagram and sharing input to that diagram (Barjis 2011).

Sections 6 and 7 identify the benefits (Table 3.1) and challenges (Table 3.2) of CBPM. These statements were identified in literature and by the pilot study in order to determine whether

organisations deem CBPM beneficial or find it challenging. Section (S9) relates to the roles played by participants in BPM sessions and the status of CBPM in organisations (Barjis 2011; Poppe *et al.* 2011). The last section (S10) relates to tools used by organisations for BPM.

A research instrument's quality is essentially evaluated with respect to validity (face validity and content validity) and reliability (Saunders *et al.* 2009). Face validity is confirmed if the questions found in the questionnaire originate from and is based on literature. A pilot study can be carried out in order to establish the content validity of a questionnaire. Reliability is based on internal consistency which includes the inter-correlation, uniformity and equivalence among the questions in the questionnaire. Face validity is therefore established as each question is either based on literature or on the initial pilot study (Section 3.4).

A pilot study was carried out in order to establish the content validity of the survey for CBPM. Two participants from industry, with a modelling background, completed the survey for the pilot study and no ambiguity was recorded. The participants were satisfied with the content of the survey and no changes needed to be made to the questionnaire. Reliability was established by measuring Cronbach's alpha values and all of the values were acceptable for an initial exploratory study. An acceptable Cronbach's alpha value is any value larger than 0.7 (Nunnally 1978) and it shows consistency between the elements. Nunnally (1978) states that a Cronbach's alpha value between 0.50 and 0.69 shows evidence of reliability in the early stages of research.

The section on *Benefits of BPM* (S3) scored a Cronbach's alpha value of 0.82 (Appendix P) which is higher than 0.7 and shows consistency between the benefits. The section on *BPM Challenges* (S4) received a Cronbach's alpha value of 0.8 (Appendix P) which shows consistency between the challenges. The section on *Success Measures for BPM* (S5) was also acceptable since it received an acceptable Cronbach's alpha value of 0.71 (Appendix P).

The section on *Challenges of CBPM* received a Cronbach's alpha value of 0.67 which is lower than the acceptable value, however, it is acceptable for exploratory studies (Nunnally 1978). The challenge *Not having multi-touch computers makes collaboration difficult* was removed from the challenges and the Cronbach's alpha value increased to an acceptable value of 0.73 (Appendix P), making the Cronbach's alpha value acceptable.

The section on *Benefits of CBPM* received a Cronbach's alpha rating of 0.89 (Appendix P) which is an acceptable value and shows consistency between the CBPM benefits. The section on *CBPM Success Factors* received a Cronbach's alpha value of 0.64 (Appendix P) which is below the accepted industry standard but is acceptable for an exploratory study (Nunnally 1978). Lastly, the section on *CBPM Status* received a Cronbach's alpha value of 0.59 which is below the accepted industry standard (Institute for Digital Research and Education 2013; Nunnally 1978) but it is acceptable for an exploratory study (Nunnally 1978). If the statement *You collaborate by sharing your business process models via email* is removed, the Cronbach's alpha value increases to an acceptable value of 0.79 (Appendix P). Therefore, all of the final updated sections received an acceptable Cronbach's alpha value which indicates that the questions in each section are consistent.

3.5.3. Participant Profile and Results

A profile consisting of 45 participants from 19 companies completed the BPM Survey. A cover letter (Appendix F) was sent to IT managers at approximately 25 organisations requesting them and one or more colleagues to complete a survey for CBPM. The participants completing the survey have to come from a consulting organisation in which they carry out BPM activities for other organisations. The majority of known job titles who completed the survey (Figure 3.5) were Business Analysts (33%) whilst many participants selected "Other" as their job title (35%). Other job titles included: Software Developer, Project Manager, Industrial Engineer, Support Executive, Account Manager, Quality Assurer, Consultant and Technology Enabler.
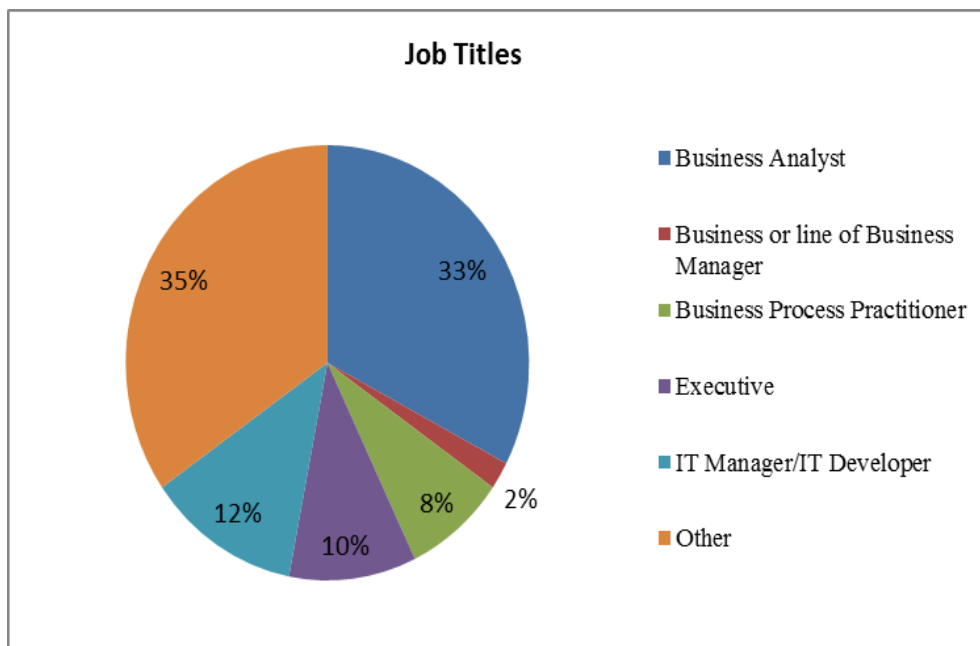
Figure 3.5: Job titles

Approximately 67% of the companies surveyed have fewer than one hundred employees (Table 3.4), 60% operate in the Computers/Consumer/Electronics/Software industry (Table 3.5) and 66% are based in Gauteng (Table 3.6). Approximately 45% of the companies have between five and 20 people involved with BPM (Table 3.7).

Table 3.4: Organisation size

Number of Employees in Organisation	Percentage of Respondents' Answers
< 100	67 %
100 – 500	22 %
> 500	11 %
Total	100%

Table 3.5: Type of industry

Industry	Percentage of Respondents' Answers
Computers/Consumer/Electronics/Software	60 %
Distribution/Supply chain	6 %
Education	6 %
Financial services/Insurance	6 %
Health care/Medical	6 %
Other	16 %
Total	100%

Table 3.6: Organisation's locations

Province Where Organisation is Located	Percentage of Respondents' Answers
Gauteng	66 %
Eastern Cape	11 %
Western Cape	17 %
Outside SA	6 %
Total	100%

Table 3.7: Number of people involved with BPM

Number of People Involved with BPM	Percentage of Respondents' Answers
< 5	33 %
5 – 20	45 %
> 20	22 %
Total	100%

The participants were asked to indicate which roles they had played in BPM sessions and were allowed to select more than one role. The results (Figure 3.6) indicate that most participants have played the role of an expert modeller (76%) or an analyst (71%).
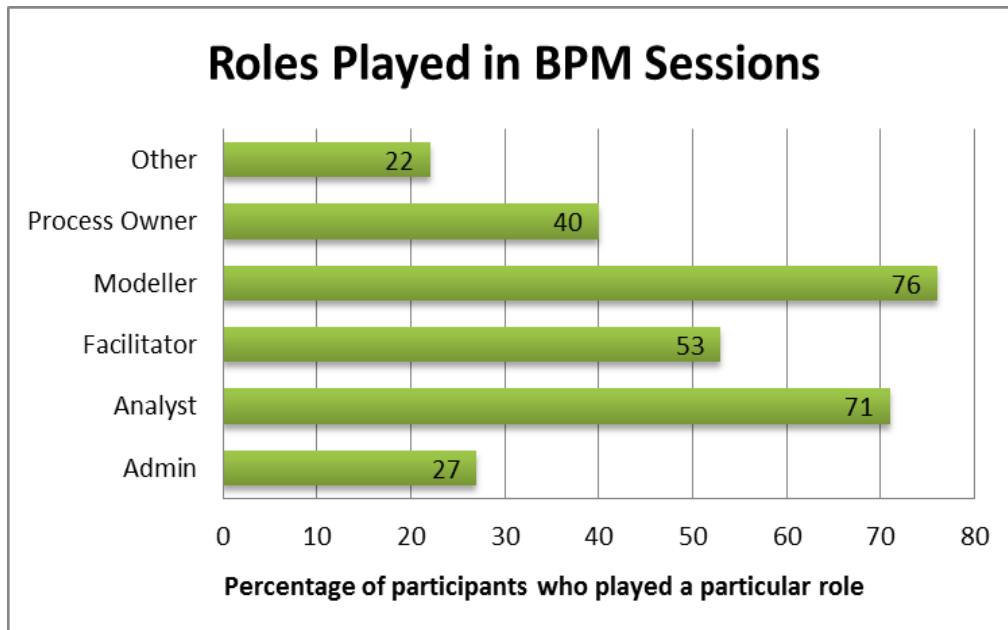
Figure 3.6: Percentage of roles played in BPM sessions

The participants were asked to rate four features of a BPM tool (S2) that they perceived as important in their organisation (Table 3.8). The rating was on a 5-point Likert scale, with 1 being *Not Important* and 5 being *Very Important*. *"The ability to store models and processes in a data repository"* was identified as the most important factor with a mean score greater than four (μ = 4.29) and a standard deviation (σ) of 0.73 which indicates that all of the responses were close to the overall mean score. The feature that scored the lowest mean value (μ = 3.11) is *"The ability to post models on the web so that they can be widely shared"*. This indicates that this feature is deemed the least important and participants feel *neutral*[2] towards this feature and *positive* towards the other features.

---

[2] According to the consulted statistician, the mean scores are divided into three ranges: Negative = [1 - 2.6); Neutral = [2.6 - 3.4] and Positive = (3.4 – 5].

Table 3.8: Features of a BPM tool that are perceived as important

Feature	Valid n	Mean	Minimum	Maximum	Standard Deviation
The ability to store models and process data in a repository.	45	4.29	3	5	0.73
Collaborative Modelling (The ability of the tool to support multi-stakeholder collaborative modelling).	45	3.71	1	5	1.20
The ability of the tool to support multi-modeller collaborative modelling.	45	3.64	1	5	1.11
The ability to post models on the web so that they can be widely shared.	45	3.11	1	5	1.25

The participants were also asked to complete open-ended questions in which they had to list any other features of a BPM tool that they deemed important. Thematic analysis was used to analyse the qualitative data (Creswell 2009) in which the researcher identified themes. Only 13 participants listed extra features and in most cases the features identified varied. Seven percent (f[3] = 3) of participants said that *the tool should be easy to use*, 4% (f = 2) indicated that *it is important that the model can be reported on upon completion*, 4% (f = 2) said that *it is important that the tool allows modellers to track changes* and 2% (f = 1) stated that *the tool should allow for notes or annotations*. These additional features are listed in Table 3.9.

Table 3.9: Features of a BPM tool

Features of a BPM tool	Frequency (f)
The tool must allow for easy exporting of models	2
The tool should be agile and usable	2
The tool should cater for templates to be created	2
The tool must have the ability to link to sub-processes	1
The tool should support EPC and BPMN modelling standards	1

---

[3] Frequency (f) refers to the number of participant responses to a particular theme in thematic analysis.

Participants were asked to rate the perceived benefits of BPM for their organisation (Table 3.10). All of the benefits received mean scores of four or greater than four which means they were all in the *positive* range. "*Understanding*" ($\mu = 4.62$), "*process improvement*" ($\mu = 4.60$) and "*communication*" ($\mu = 4.47$) had the three highest mean ratings. This confirms the study of Indulska *et al.* (2009a) citing these as important benefits of BPM to organisations. Participants were also asked to list any other benefits of BPM to their organisations. Two new benefits not identified in the theoretical model were the "*improved ability to consult with clients*" and the fact that "*BPM allows one version of the truth that is well managed and maintained*".

Table 3.10: Benefits of BPM

Benefit	Valid n	Mean	Minimum	Maximum	Standard Deviation
Understanding	45	4.62	4	5	0.49
Process improvement	45	4.60	3	5	0.65
Communication	45	4.47	2	5	0.66
Model-driven process execution	45	4.02	2	5	0.92
Process performance measurement	45	4.00	2	5	0.88

Participants gave all the challenges of BPM (Table 3.11) ratings with mean scores between three and four ($3.2 \leq \mu \leq 3.58$) on a 5-point Likert scale. These scores indicate that participants gave *neutral* to *positive* ratings, in terms of agreeing with the challenges. The standard deviation scores are all mostly above one ($0.99 \leq \sigma \leq 1.41$) however, this is still fairly low indicating that all of the responses were close to the mean score. The participants were also asked to list any other challenges of BPM to their organisations (Table 3.12). Seven participants gave challenges, however, three of the challenges overlapped with the challenges in Table 3.11.

Table 3.11: Perceived challenges of BPM

BPM Challenge	Valid n	Mean	Minimum	Maximum	Standard Deviation
Modelling level of detail	45	3.58	1	5	0.99
Standardisation	45	3.58	2	5	1.08
Ease of use (tool)	45	3.42	1	5	1.41
BPM expertise	45	3.33	1	5	1.09
Model management	45	3.20	1	5	1.12

Table 3.12: Other challenges listed by participants

Challenges	Frequency (f)
Some clients are not receptive to BP models, this could be because they are overseas and communication of process models via remote presentation tools and email does not work well	1
Building a library of processes	1
Sufficient documentation	1
Drill-down capability of models	1

Participants agreed with all of the success measures of BPM (Table 3.13) identified by Sedera *et al.* (2004) and Bandara *et al.* (2005). *"Efficiency"*, *"effectiveness"*, *"user satisfaction"*, *"process model quality"* and *"model use"* all received a mean rating greater than four (4.31$\leq \mu \leq$ 4.56) indicating that participants gave *positive* ratings to all of the success measures. *"Modeller's satisfaction"* received a mean rating greater than three ($\mu = 3.80$) which is also a *positive* rating. All of the standard deviation scores are below one or close to one (0.58 $\leq \sigma \leq$ 1.01) indicating that all the participants selected values close to the mean value.

Table 3.13: Success measures of BPM

Measure	Valid n	Mean	Minimum	Maximum	Standard Deviation
User satisfaction	45	4.56	3	5	0.59
Model use	45	4.51	3	5	0.59
Effectiveness	45	4.51	3	5	0.63
Process model quality	45	4.42	3	5	0.58
Efficiency	45	4.31	2	5	0.73
Modeller's satisfaction	45	3.80	1	5	1.01

Participants gave all the benefits of CBPM (Table 3.14) a *positive* rating ($3.53 \leq \mu \leq 4.29$). The benefit "*Sharing ideas, opinions and different points of view between modellers*" scored the highest mean value ($\mu = 4.29$) amongst all of the listed benefits. The standard deviation is relatively low ($0.76 \leq \sigma \leq 1.16$) which indicates that the participants agreed on most of the scores. "*Confidence amongst modellers*" received the lowest mean score ($\mu = 3.53$) however it is still a *positive* rating.

Table 3.14: Benefits of CBPM

Benefit	Valid n	Mean	Minimum	Maximum	Standard Deviation
Sharing ideas, opinions and different points of view between modellers	45	4.29	2	5	0.76
Learning from other modellers	45	4.20	2	5	0.87
Increased understanding of the process amongst modellers	45	4.09	2	5	0.82
Brainstorming amongst modellers	45	4.09	2	5	0.87
More accurate modelling since more than one modeller is involved	45	3.84	1	5	1.09
Shared ownership of the process amongst modellers	45	3.60	1	5	1.16
Confidence amongst modellers	45	3.53	2	5	1.06

Participants gave *positive* ratings to the challenges of CBPM (Table 3.15). The mean values are all higher than three ($3.44 \leq \mu \leq 3.87$) with standard deviation scores that are above one ($1.04 \leq \sigma \leq 1.25$).

Table 3.15: Challenges of CBPM

Challenge of CBPM	Valid n	Mean	Minimum	Maximum	Standard Deviation
Having different interpretations of the process from each modeller	45	3.87	1	5	1.06
Difficulties of integrating and combining different versions of models and model changes	45	3.69	1	5	1.04
Time management - people aspect	45	3.62	1	5	1.25
Time management - technical aspect	45	3.47	1	5	1.22
Technology constraints with Desktop PCs	45	3.44	1	5	1.14

Participants were asked to list any other challenges of CBPM that they face in their organisations (Table 3.16). The results confirmed the studies of Indulska *et al.* (2009b) who identified *"standardisation"* and *"ease of use"* as challenges (Section 2.4) as well as Barjis (2011) who documented *"multiple stakeholders" (different interpretations of processes)* and *"time management"* as challenges (Section 3.4).

Table 3.16: Other challenges of CBPM

Challenges of CBPM	Frequency (f)
Standardisation	1
Ease of use	1
Problems with the CBPM tool	1

Participants agreed in terms of the CBPM success factors (Table 3.17) with mean values higher than three ($3.73 \leq \mu \leq 4.64$) and most of the standard deviation scores less than one ($0.53 \leq \sigma \leq 1.19$). This indicates that all of the ratings were *positive* and all of the ratings were close to the mean score. *"User participation"* received the highest mean score and *"Modelling Tool"* received the lowest mean score. Participants were asked to list any other CBPM success factors which they deemed important.

Table 3.17: CBPM CSFs

CBPM Success Factor	Valid n	Mean	Minimum	Maximum	Standard Deviation
User participation	45	4.64	3	5	0.53
Time resources	45	4.02	2	5	0.72
Modellers giving different inputs and interpretations of the processes	45	3.87	1	5	0.89
Drawing only one diagram	45	3.78	1	5	1.06
Modelling tool	45	3.73	1	5	1.19

Participants were also asked to rate several statements on CBPM to determine what the CBPM statuses in the different organisations are (Table 3.18). Most of the mean values are greater than three except for: "*You collaborate by sharing your BP models via an internet portal*" which has a mean value below three (μ = 2.80). This statement has also received the highest standard deviation (σ = 1.44). The other mean values (3.13 $\leq \mu \leq$ 3.69) are between *neutral* and *positive* ratings. Participants indicated that their "*experiences with CBPM had been positive*" (μ = 3.69) and that their "*modelling tool allowed for multiple modellers to effectively access the models*" (μ = 3.38).

Table 3.18: CBPM status in organisations

CBPM Status	Valid n	Mean	Minimum	Maximum	Standard Deviation
Your experience with CBPM has been positive	45	3.69	1	5	1.04
Your BPM tool allows multiple modellers to effectively access your models	45	3.38	1	5	1.15
In your organisation, BPM activities are carried out in a collaborative manner	45	3.36	1	5	1.07
Your BPM tool allows multiple modellers to effectively update BP models each from their own device	45	3.20	1	5	1.25
More than one modeller collaborates on a model or on a set of models	45	3.13	1	5	1.14
You collaborate by sharing your business process models via an internet portal	45	2.80	1	5	1.44

Participants were asked to list any reasons why CBPM has not been a positive experience in their organisations. The responses from participants are documented in Table 3.19. The theme with the highest frequency of responses (f = 8) is *sharing ideas leads modellers to disagreeing* and the second highest frequency (f = 7) is *the organisation only uses one modeller*. Three participants indicated that *the tool does not allow for CBPM* and all of the other themes were created based on a frequency of one response.

Table 3.19: Reasons why CBPM has not been a positive experience

Reasons	Frequency (f)
Sharing ideas leads to modellers disagreeing	8
The organisation only uses one modeller	7
The tool does not allow for CBPM	3
Time constraints	1
Budget constraints	1
There is no standard for CBPM	1

Participants were also asked to indicate what technology they use for CBPM in their organisations (Table 3.20). The "*desktop PC*" received the highest mean score ($\mu = 4.49$) and is the only *positive* rating. The rest of the statements scored between *negative* and *neutral* ratings. This result indicates that most people use "*desktop PCs*" for CBPM and possibly "*multiple displays in a single location*" ($\mu = 3.27$) but they do not really make use of "*multi-touch surfaces*" ($\mu = 1.76$). Participants were also asked to list any tools that they use for CBPM. The responses include laptops, traditional whiteboards, web-based tools and brown papering.

Table 3.20: Tools used for BPM in organisations

Tool	Valid n	Mean	Minimum	Maximum	Standard Deviation
Desktop PC	45	4.49	1	5	1.01
Multiple displays (technologies) in a single location	45	3.27	1	5	1.42
Interactive Whiteboard	45	2.84	1	5	1.52
Tablet PC	45	2.11	1	5	1.39
Multi-touch Surface	45	1.76	1	5	1.21

This section discussed the results of the survey for CBPM. The results showed that participants mostly confirmed the benefits, challenges and measures for BPM identified in theory. Participants also mostly agreed with the benefits, challenges and CSFs for CBPM. Therefore, the factors identified in literature were validated by means of the survey and will be incorporated into the framework (Section 3.6).

3.6. Framework for CBPM (Version 1)

The benefits of BPM have been verified by the survey for CBPM and added to the benefits of CBPM. The challenges of BPM identified in theory and verified by the survey for CBPM have been added to the challenges of CBPM. The identified benefits and challenges of CBPM satisfies research objective one, "*Identify the benefits and challenges of CBPM*". In the framework for BPM, one CSF for BPM was defined, namely, modelling tool (Sedera *et al.* 2004; Bandara *et al.* 2005). Four additional CSFs relevant to CBPM were identified (Lee *et al.* 2000; Barjis 2011; Poppe *et al.* 2011). The five CSFs for CBPM (Table 3.17) identified in literature were verified by the survey for CBPM since they were all in the *positive* range ($3.73 \leq \mu \leq 4.64$). This satisfies research objective two, "*Identify the critical success factors and success measures of CBPM*". The six measures of BPM were all verified in the survey since they were all in the *positive* range ($3.8 \leq \mu \leq 4.56$). They are BPM success measures but they are still applicable to CBPM (Table 3.13).

An updated framework was created which has additional aspects compared to the framework presented in Chapter 2. The benefits of collaboration, challenges of collaboration and CSFs of collaboration are the aspects that have been added to the framework (Figure 3.7).

The benefits, challenges and CSFs that have been added to the framework, are the top benefits, challenges and CSFs as rated by industry participants in the survey for CBPM.

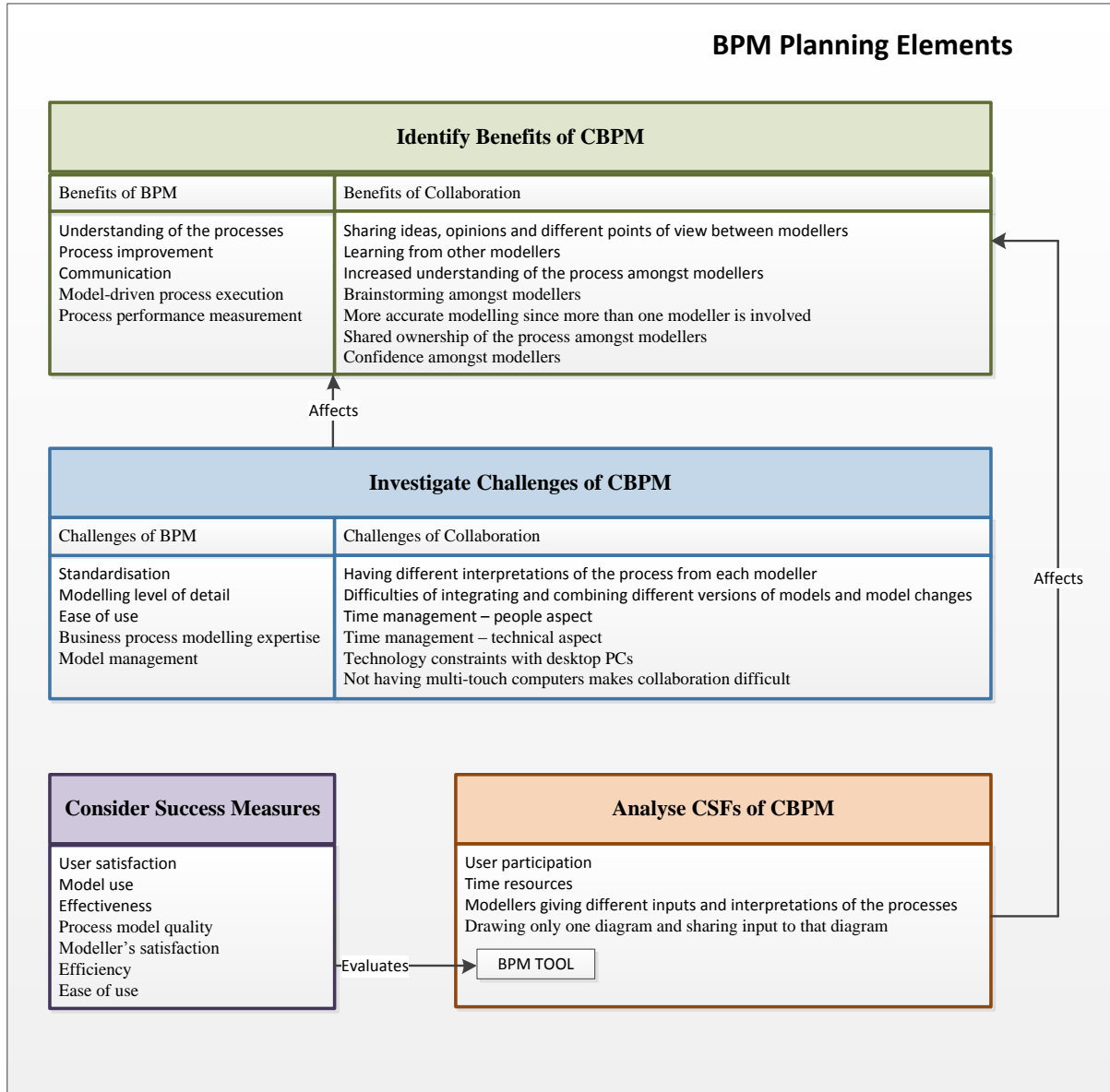**Figure 3.7: Framework for CBPM (version 1)**

3.7. Conclusion

BPM is a collaborative activity in which all of the relevant stakeholders should participate. Conducting BPM in a collaborative environment allows more input to be taken into consideration which can eliminate redundancies and ambiguities. "*Understanding of the processes*", "*process improvement*" and "*communication*" are the top three perceived

benefits of BPM. The top three benefits of CBPM as perceived by South African organisations who took part in the survey are the *"sharing of ideas, opinions and different points of view between modellers"*, *"learning from other modellers"* and *"increased understanding and brainstorming amongst modellers"*.

"Standardisation", *"modelling level of detail"* and *"ease of use"* are the top three perceived challenges of BPM. The challenges for CBPM as perceived by industry are *"having different interpretations of the process from each modeller"*, *"difficulties of integrating and combining different versions of models* and *time management"*.

Several CSFs for CBPM were identified in theory (Chapter 2) and were empirically validated by a survey of South African organisations and are *"user participation"*, *"time resources"*, *"modellers giving different inputs and interpretations of the processes"*, *"drawing one diagram and sharing input to that diagram"* and *"modelling tool"*. The importance of collaboration was also highlighted.

The success measures for BPM were also identified (Chapter 2) and verified in this chapter, namely: *user satisfaction*, *model use*, *effectiveness*, *process model quality*, *efficiency* and *modeller's satisfaction* (Table 3.13). The research objectives *"Identify the benefits and challenges of CBPM"* and *"Identify the critical success factors and success measures of CBPM"* have been met and therefore, the first two research questions of this study have been answered:

RQ_1: *"What are the benefits and challenges of CBPM?"*
RQ_2: *"What are the critical success factors and success measures for CBPM?"*

This chapter completed the first activity of DSR which was to identify the problem and motivate it (Section 1.10.2). The challenges of CBPM highlight the problem of CBPM and the need for a solution. The next chapter will discuss the objectives and requirements of a solution for co-located CBPM. These include different kinds of collaboration, technologies supporting collaboration and the theory of collaboration. The aim of Chapter 4 is to highlight the importance of collaboration and to identify what technologies can be used for collaboration in order to create a framework for CBPM.

Chapter 4

Objectives of a Collaborative Business Process Modelling Touch Solution (BPMTouch)
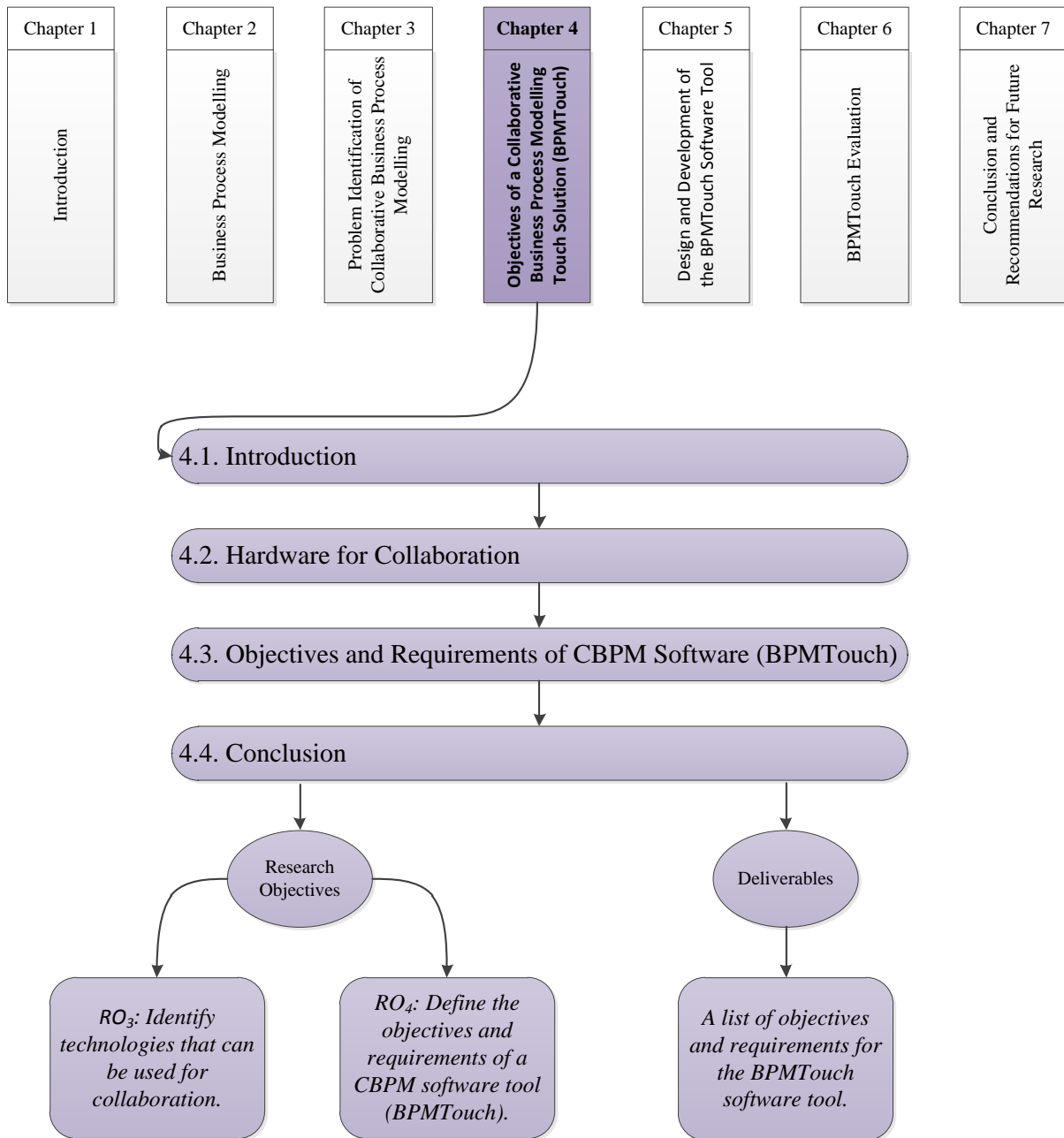
4.1. Introduction

In the previous chapter the research problem was examined in more detail and several benefits, challenges and CSFs of CBPM were identified by means of an evaluation of CBPM and an industry survey of BP modellers in South African organisations. This chapter formalises the next step of the DSR methodology which is to define objectives for a solution (Peffers *et al.* 2007). A layout of Chapter 4 and the deliverables is shown in Figure 4.1. The research questions addressed in this chapter are:

RQ3: "What technologies can be used for collaboration?"
RQ4: "What are the objectives and requirements of a software tool (BPMTouch) for CBPM?"

The objectives, *"Identify technologies that can be used for collaboration"* and *"Define the objectives and requirements of a CBPM software tool (BPMTouch)"* will be met in this chapter. The first goal is to identify, compare and discuss technologies that support collaboration and touch input, in order to determine the best technology to be used for a CBPM solution (Section 4.2). The second goal that must be addressed in this chapter is therefore to identify the objectives, functional and non-functional requirements for a software tool for CBPM (Section 4.3). A conclusion of the results of this chapter will also be presented (Section 4.4).

.

Chapter 1	Chapter 2	Chapter 3	**Chapter 4**	Chapter 5	Chapter 6	Chapter 7
Introduction	Business Process Modelling	Problem Identification of Collaborative Business Process Modelling	**Objectives of a Collaborative Business Process Modelling Touch Solution (BPMTouch)**	Design and Development of the BPMTouch Software Tool	BPMTouch Evaluation	Conclusion and Recommendations for Future Research

4.1. Introduction

4.2. Hardware for Collaboration

4.3. Objectives and Requirements of CBPM Software (BPMTouch)

4.4. Conclusion

Research Objectives

Deliverables

RO₃: Identify technologies that can be used for collaboration.

RO₄: Define the objectives and requirements of a CBPM software tool (BPMTouch).

A list of objectives and requirements for the BPMTouch software tool.

Figure 4.1: Chapter 4 layout and deliverables

4.2. Hardware for Collaboration

In order to implement a CBPM tool, a suitable hardware platform is required and most of the existing platforms for BPM only cater for single users (Rittgen 2008). This section will discuss possible hardware platforms that allow for multiple modellers and which could be

implemented as a solution for CBPM. Multi-touch surfaces are large touch-based surfaces that allow multiple people to interact simultaneously (Section 4.2.1). Interactive white boards are large white boards that are used in conjunction with a computer and are ideal for group environments (Section 4.2.2). Tablet PCs are touch-based mobile devices with similar capabilities to computers and these have been investigated for collaborative use (Section 4.2.3). Multiple displays in a single location refer to output onto several displays in a single location (Section 4.2.4).

4.2.1. Multi-touch Surface

A multi-touch surface is considered as the most suitable technology to use in a collaborative environment for small teams of people (Scott, Sheelagh and Carpendale 2004). The multi-touch surface is a co-located collaborative technology that allows individuals to interact together on one surface using their fingers as a means of touch input instead of a keyboard or mouse (Kammer *et al.* 2010). Using this type of input is a direct way of interacting with the screen and it has been reported to feel like a more natural approach (Figure 4.2). Several studies have investigated multi-touch surfaces for collaborative work and they all had positive results (Hornecker *et al.* 2008; Hunter and Maes 2008; Kammer *et al.* 2010; Sams, Wesson and Vogts 2011).

Hornecker *et al.* (2008) studied different facets of awareness with multi-touch input and multi-mice input on multi-touch surfaces and discovered that higher levels of awareness were achieved for the multi-touch input. Hunter and Maes (2008) carried out a study in which they presented "WordPlay" which is a collaborative multi-touch surface interface for the creation, organisation and exploring of ideas and the results were positive indicating that "WordPlay" provides a space in which users can explore words together in a social context. Kammer *et al.* (2010) carried out a study in which they investigated several strategies that could lead to the formalisation of gesture interaction and created GeForMT a formalised gesture interaction tool for developers that can be used for developing software for multi-touch surfaces.

Figure 4.2: Example of a multi-touch surface (Hunter and Maes 2008)

Multi-touch surfaces allow multiple individuals to interact with the surface simultaneously thereby providing an environment in which the individuals can collaborate while interacting with the surface (Hornecker *et al.* 2008; Hunter and Maes 2008). Multi-touch technology allows individuals in a collaborative environment to make decisions together by creating possibilities and allowing for visualisation of and sharing of ideas and providing a more intuitive means of interaction. Several individuals can interact together due to the ability of simultaneous input/interaction supported by multi-touch surfaces. This is advantageous as all the individuals can take part in the activities and the discussion while interacting on the surface. Individuals do not have to sit and watch one person working and everyone's input can be taken into account.

Using a multi-touch surface in a collaborative environment poses many benefits, such as being able to see other participants' body language, participants' pointing to objects on the surface and discussing the work at hand together (Clifton, Mazalek and Sanford 2011). The benefits of a multi-touch surface can lead to reduced time and costs. The multi-touch surface provides users with the opportunity to interact while being aware of other people and being able to rotate objects on the multi-touch surface, just as one would be able to do on/around a traditional table. The use of the mouse also requires more concentration from the participants than touch input (Hornecker *et al.* 2008).

Different ways of collaborating around a multi-touch surface exist and a study done by Isenberg *et al.* (2010) reported that when participants work in a co-located collaborative

environment around a multi-touch surface they could solve a complex task successfully. From their study they documented eight styles in which participants can collaborate within different activities (Figure 4.3). These styles range from close collaboration styles (a discussion about the subject matter) to loose collaboration styles (one participant working while the other participant is not engaged in the work at all). People do not collaborate in the same manner and different collaboration styles work differently to solve problems.

The DISC collaboration style (Figure 4.3) refers to a discussion between participants about the work at hand, VE refers to view engaged, meaning that one participant works while another participant watches and can make comments. SV indicates that participants share the same view whilst working on a subject at hand; this could include from reading documents to moving objects around. SIDV refers to the sharing of the same information at different views meaning that participants interact with the same data but they each have their own copy of the data. SSP refers to the same specific problem, which relates to work being undertaken to solve a shared problem that has been clearly specified. In this case participants do not work from the same document but will read documents relating to the same problem from a shared set of documents.

The SGP collaboration style refers to the same general problem relating to participants working on the same problem but finding the data for the problem from different places and working from their own angle towards solving the problem. DP refers to different problems, in which case participants do not work together on solving the same piece of a problem but instead focus on solving different aspects of a problem. D refers to disengaged in which case one participant interacts with the subject matter while the other participant does not take part at all.
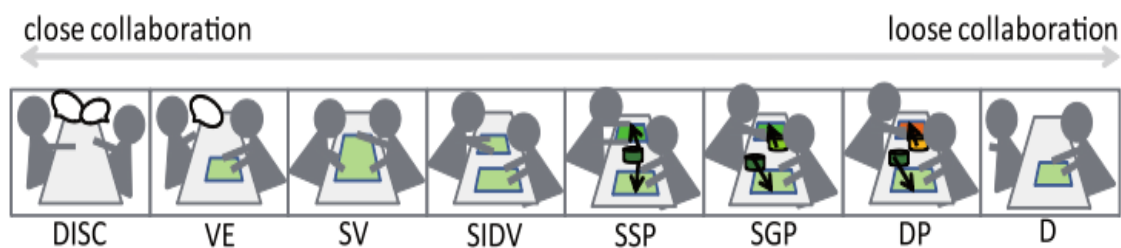

Figure 4.3: Collaboration styles around a multi-touch surface (Isenberg *et al.* 2010)

Although there are several collaboration styles and benefits for multi-touch surfaces, the limitations also need to be taken into consideration. Multi-touch surfaces have several limitations:

- Small text needs to be avoided and the "fat finger" is a common problem with designing applications for large multi-touch surfaces (Apted and Kay 2008);
- The lighting needs to be dim so that the screen can be clearly visible (Derizemlya 2009);
- Large multi-touch surfaces are immobile (Derizemlya 2009); and
- Large multi-touch surfaces are very expensive (Derizemlya 2009).

The "fat finger" phenomenon is that everything represented on the surface must be large enough so that a fat finger can select the objects and manipulate them. If objects are not big enough, participants will find it difficult and frustrating to interact with and manipulate the objects on the surface.

4.2.2. Interactive Whiteboard

An interactive whiteboard (IWB) is a whiteboard that allows teachers and pupils to interact with the whiteboard, thus controlling the PC from the whiteboard instead of utilising a keyboard and mouse (Becta ICT Research 2004). Figure 4.4 shows how the projector, IWB and computer are used together. IWBs also fall under the term touch technology as it detects the presence and position of touch input within an IWB display (Hwang, Wu and Kuo 2013). Nolan (2008) carried out a study in which she explored the different possible uses of IWBs in music classrooms. The results concluded that teachers can teach notation and composition with the IWB, students can interpret music by drawing different phrases, the internet resources can be used to stream music and students can read music from the IWB. Students found composing on the IWB easy as they merely had to touch a note and drag it to the desired location on the IWB.

In many classrooms in the United Kingdom, IWBs have replaced flipcharts and whiteboards (Kershner and Warwick 2006). The IWBs can aid in the preparation of lectures as well as transform certain factors of teaching.
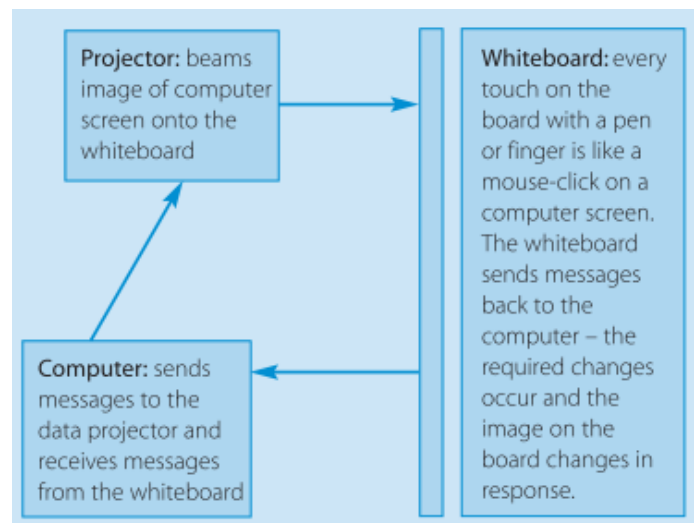
Figure 4.4: How an IWB functions (Becta ICT Research 2004)

Another study was conducted with the aim of identifying how IWBs impacted the students' learning (Northcote *et al.* 2010). One of the tasks involved the teacher drawing two pictures with the same items. IWBs are technologies that allow for collaboration and are currently being used in classroom environments to increase the depth and speed of learning (Becta ICT Research 2004). Renger *et al.* (2008) carried out investigations to determine users' experiences when using IWBs in collaborative modelling sessions. IWBs are advantageous in a CBPM environment as users can edit the model directly which inspires participation and joint ownership. The benefits of IWBs in an education environment are that they (Becta ICT Research 2004):

- Allow for preparation and access to saved work;
- Access multimedia;
- Increase student involvement in class;
- Provide immediate feedback;
- Reduce student fear of making mistakes;
- Allow for collaboration; and
- Increase speed of learning.

In spite of the potential benefits of IWBs in educational environments, they are extremely expensive and are immobile. The other limitations of IWBs identified in an education environment are that (Becta ICT Research 2004):

- Teachers will require training;

- Teachers will require time to become familiar with the IWB;

- IWBs must be maintained (replacing filters); and

- Installation must be done by a professional.

4.2.3. Tablet PCs

Tablet PCs can be used as an alternative to an IWB (Becta ICT Research 2004). A tablet PC can be wirelessly connected to a projector. Content can then be drawn on the tablet PC which can be projected onto a projection surface. The advantage of using a tablet PC over an IWB is that it is mobile but a disadvantage is that it can be slow due to the wireless connection. There are however several schools in the United Kingdom that prefer the use of tablet PCs over IWBs as it is they are more cost effective and versatile than an IWB (Twinning *et al.* 2005).

In a study conducted by Hinckley (2003) the use of synchronous gestures in mobile devices is explored. The synchronous gestures refer to particular patterns of activities (Hinckley 2003). The outcomes of these patterns change when the activities take place simultaneously. Different devices give off different signals which are picked up by corresponding devices when they come into contact. Tablet PCs connected via a wireless network were used throughout Hinckley's study. Dynamic display tiling is a way by which individuals can bring together the displays on different tablet PCs (Figure 4.5). This is achieved by softly bumping a tablet PC in an individual's hand against a still tablet PC lying on a desk. When the individual bumps the tablet PCs, one display is created. When a tablet PC is picked up, it is detached from the joint display. Information can be shared among tablet PCs by bumping the tablet PCs against each other.

Data can also be sent from one tablet PC to another by "pouring" the data to the other tablet PC. The "pouring" of data is done by angling the tablet PC containing the data downwards when bumping the other tablet PC. The arrows in the second row of Figure 4.5 indicate that a connection is established between the tablet PCs. The size of the arrows shows the hierarchy of the relationship where the base tablet PC contains a smaller arrow than the connecting tablet PC. The tablet PCs can connect both horizontally and vertically.

Figure 4.5: Sequence of tiling displays horizontally (Hinckley 2003)

Another synchronous gesture developed is known as stitching (Hinckley, Ramos and Guimbretiere 2004). Stitching involves the use of a pen to connect to mobile devices (Figure 4.6). The gesture uses a pen and spans over several displays by starting the motion on one screen, skipping over the edges of the screen and ending on the screen of a separate device. In this way, a shared working area for collaboration is created.
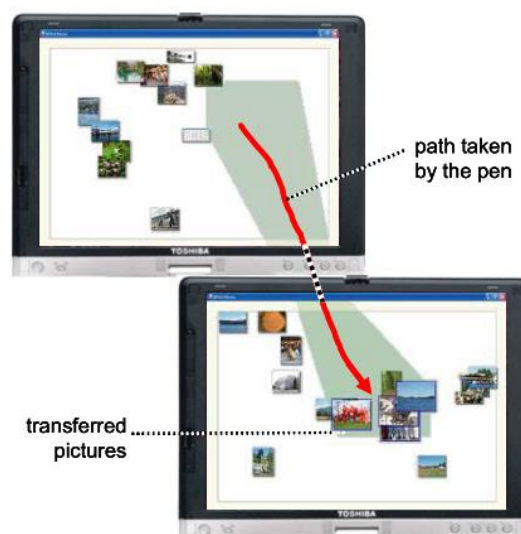

Figure 4.6: Sharing of photos between two tablets by stitching from one tablet to another
(Hinckley *et al.* 2004)

Tablet PCs are mobile devices and mobility is becoming the norm in organisations (Brandford 2012). Laptops and mobile phones are being replaced by smartphones and tablet PCs as these allow users to move some of their IT away from laptops and desktops to tablet PCs and smartphones instead. Tablet PC and smartphone consumers can use their devices for work, a term referred to as bring your own device (BYOD). There has been a recent gain in momentum in BYOD movement by which employees take their personal mobile devices to work and use them to carry out their work activities (Technology Evaluation Centers 2013). They can then access the corporate tools and systems. There are however challenges such as secured management for organisational use and a proper network needs to be in place so that employees can use the Wi-Fi and internet from their devices (Brandford 2012).

Benavent, Belmonte and Bonastre (2006) conducted a study in which they used a framework known as Classroom Presenter and tablet PCs to document students' experiences while collaborating in such a learning environment. The results of the study indicated that students understood the lectures more, their attention was increased and real-time interaction between the students and instructor increased.

Tablet PCs have been shown to be very beneficial in a classroom environment as they aid in collaboration and interaction between the students and the teacher, as well as among students (Benavent *et al.* 2006; Berry and Hamilton 2006). The benefits of tablet PCs (Twinning *et al.* 2005; Berry and Hamilton 2006) are summarised in Table 4.1.

Tablet PCs have several benefits but they also have some limitations (Twinning *et al.* 2005). The cost of tablet PCs is higher than the cost of laptops with comparable specifications. Tablet PCs also have low screen illumination which makes it challenging to work with them outside in the light and they have a slow boot-up speed. Tablet PCs are also very time consuming to set-up and slow networks limit the use of these devices. Accessories such as pens and stylists that can be used with a tablet can further be misplaced.

Table 4.1: Benefits of Tablet PCs

Benefit of Tablet PCs	Reference
Allows for collaboration by having pairs of students sharing a tablet PC, increasing problem solving and brainstorming opportunities and creating slides in a collaborative environment	Twinning *et al.* (2004) Berry and Hamilton (2006)
Tablet PCs are portable and mobile	
People can focus on one tablet simultaneously	Berry and Hamilton (2006)
Work can be saved, viewed and altered at a later stage	
Quick changes can be made to work as opposed to hard copies	
Improved communication	Twinning *et al.* (2004)
More motivation to attempt work using the tablet	
Assists students in developing their motor control skills	
Supports audio and video	
Robust	
Child friendly	

Despite the limitations of tablet PCs, sales have risen globally. Based on the sales figures of Kalahari.com and Takealot.com, more tablet PCs were sold than desktop PCs in 2012 (Chapter 1). Most of the traffic going to Kalahari.com comes from desktop PCs and mobiles, however, the traffic from tablet PCs grew over 300% between November 2011 and November 2012 (BusinessTech 2013a). The global forecast is that tablet PC sales will surpass desktop PC sales. Lenovo, the top PC company in the world, outperformed its competitors for 18 consecutive quarters and is now fourth globally with smartphone and tablet PC sales (Whitney 2013). Lenovo's tablet PC shipments reached a new record high of 2.3 million in 2013. Globally, the tablet PC shipments for the first quarter of 2013 reached 49.2 which is a 142.4% increase compared to the first quarter of 2012 (BusinessTech 2013b).

4.2.4. Multiple Displays in a Single Location

A Distributive Display Environment (DDE) is an environment in which output is displayed on multiple displays and it is evident that a computer can output to multiple displays (Hutchings,

Stasko and Czerwinski 2005). Co-located collaboration can occur in a DDE (Inkpen and Mandryk 2005). It is a challenge to evaluate co-located collaboration with technology, therefore evaluating DDEs with multiple users can prove to be a challenging task. Challenges include identifying the tasks to be examined, what behaviours should be observed as well as how to determine the effectiveness of collaboration (Inkpen and Mandryk 2005). It has been suggested that one should understand how a single user functions with DDE technologies and how the user is affected, then only extend it to multi-users. Another difficult task is the evaluation of face-to-face interactions with technology as it is difficult to comprehend whether the use of technology affects interactions. It is therefore important to clearly identify the tasks and behaviours that will be evaluated in a DDE as well as to identify how the effectiveness of collaboration will be determined and evaluated.

Several studies of Multi Display Environments (MDEs) have been reported on (Hutchings *et al.* 2005; Inkpen and Mandryk 2005; Nacenta *et al.* 2006; Biehl *et al.* 2008). Multi displays in a single location are sometimes referred to as a Smart Office (Nacenta *et al.* 2006). These offices are made up of various interconnected technologies such as tablet PCs, laptops, wall-mounted displays and projected surfaces, all of which are used simultaneously. IMPROMPTU (*IMPRO*ving *M*DE's *P*otential to support *T*asks that are gen*U*ine) is a framework used for collaborating in MDEs and it is implemented mainly in C# (Biehl *et al.* 2008). The framework aids users to realise better ways of carrying out group activities in MDEs (Figure 4.7).

Figure 4.7: A multiple device environment (MDE) (Biehl *et al.* 2008)

A field study was conducted for the evaluation of the IMPROMPTU framework in which two teams of users were observed over a three week period and the results of the study indicated that the teams mostly used the framework for opportunistic collaboration and that it provided the teams with overall value (Biehl *et al.* 2008). The framework was coded to log usage data so that it could be reviewed after the user evaluations and the evaluators were able to see which applications were shared and the time span in which they were shared. The evaluators could also see whether any applications were replicated and on which device they were replicated. User feedback was collected by means of questionnaires that had to be completed every second day as well as an interview held upon completion of the field study. The users were asked to indicate their roles, to explain which parts of the framework were utilised and how the activity was affected. In the interviews, the users were asked about overall experiences and to state the strengths and weaknesses of the framework.

Section 4.2 discussed possible hardware for collaboration. All of the hardware discussed can work for a CBPM project, however, the tablet PC will be used for the CBPM software that will be developed. The reason for selecting the tablet PC is that the tablet PC sales are rising globally, tablet PCs allow for touch input, they can be used in a collaborative environment and they are mobile.

4.3. Objectives and Requirements of CBPM Software (BPMTouch)

Defining the objectives and requirements of a software tool for CBPM is an important step as it serves as input to the design and development activity of the DSR methodology. Several different techniques can be used for the process of eliciting requirements, for instance, observing potential users while they are working, interviews and surveys with stakeholders and the analysis of extant systems (Mochal 2008; Satzinger, Jackson and Burd 2011). The functional requirements and non-functional requirements of the CBPM touch (BPMTouch) solution were identified by means of surveys and by analysis of extant systems (Sections 3.3 to 3.5).

Several high level objectives were thus identified for a touch solution for CBPM. These objectives are:

- The software must allow the users to draw BP models;

- The software should cater for co-located collaboration amongst a small team of modellers (a minimum of two modellers);

- The software must support the SIDV collaboration style; and

- The software must run on a tablet PC.

The functional requirements of a touch solution for CBPM are listed in Table 4.2. The software must support BPMN, allow for collaboration and allow for coordination amongst modellers (Denise 2010) so that control can be passed to other modellers so that they too can model on the same diagram. The software should have built-in client and server capabilities so that up-to-date information can be displayed on all connected tablet PCs. Lastly, a locking mechanism needs to be implemented for multiple users to use the software synchronously in a co-located environment while working on the same model.

In addition to the functional requirements, many different non-functional requirements have been identified for the touch solution in order to address the thesis statement. The main non-functional requirements are allowing the modelling tasks to be efficiently and effectively accomplished and that the modellers be satisfied. The non-functional requirements are listed in Table 4.2.

Table 4.2: The functional and non-functional requirements of a touch solution for CBPM

Number	Requirements
Functional Requirements	
1	The software must support the BPMN
2	The software must allow users to collaborate by updating the models on all of the connected devices (showing up-to-date displays of information)
3	The software must allow for coordination
4	The software should have built-in client and server capabilities
5	Up-to-date information needs to be displayed on all tablets
6	The system must have a built-in locking mechanism
7	The software should allow multiple users to use it in the same place and at the same time (co-located and synchronous)
Non-functional Requirements	
8	Efficiency
9	Effectiveness
10	Satisfaction
11	The system must be easy to use
12	The system must be easy to learn
13	The system should be attractive to use

Several hardware platforms were explored in order to identify a suitable hardware environment for CBPM using touch. A tablet PC was selected as the most suitable hardware for the solution due to its popularity, cost and mobility.

4.4. Conclusion

In order to discuss the objectives of a solution for co-located CBPM, hardware that supported touch and collaboration needed to be investigated. In this study, the focus will be on collaborative technology that is used by individuals synchronously and in the same location (co-located). The aim of this study is to create a framework for co-located CBPM which indicates that participants must be in the same place at the same time. In order to determine which technology will be suitable for a BPMTouch solution that will form part of the

framework, several kinds of hardware that supports touch and collaboration were investigated and discussed (Section 4.2).

Several collaboration techniques and styles for multi-touch surfaces were investigated. The SIDV technique refers to distributing the same information to different views; therefore each participant has his/her own view of the same information. The software prototype (BPMTouch) that will be developed and discussed in the next chapter will cater for the use of the SIDV technique and its evaluation will require participants to interact in the SIDV way. The tablet PC is the hardware that was chosen for the BPMTouch solution as it is less expensive than other hardware, a tablet PC is mobile, allows for touch input and can be used in a collaborative environment. The research objective, *"Identify technologies that can be used for collaboration"* was met and RQ_3 *"What technologies can be used for collaboration?"* was answered (Section 4.2).

The primary high-level objectives of a touch solution for co-located CBPM were identified. These are that *the system must allow users to draw BP models*, *the software must run on a tablet PC (using touch input)* and that *the software should allow for collaboration in small teams of modellers* (Section 4.3).

The functional and non-functional requirements of the proposed BPMTouch software application were also identified (Section 4.3) which answers RQ_4: *"What are the objectives and requirements of a software tool (BPMTouch) for CBPM?" a*nd satisfies the research objective *"Define the objectives and requirements of a CBPM software tool (BPMTouch)"*. This also completes activity two of DSR, "Define objectives of a solution" (Section 1.10.2). The key requirements focus on collaboration amongst multiple participants who are able to draw a BPMN process model.

The next chapter will focus on the design and development of the BPMTouch system by taking into consideration the objectives and requirements identified in this chapter. The aim of Chapter 5 is also to define measures for evaluating the designed artifact. In this study the selected measures are usability metrics that will be used in a field study in order to examine extant systems as well as to evaluate the final BPMTouch system (the final artifact).

Chapter 5

Design and Development of the BPMTouch
# Software Tool

5.1. Introduction

Both industry modellers and student modellers struggle with CBPM, particularly with regard to the synchronisation of BP models using traditional desktop PCs and BPM software. A pilot study was carried out by BP modellers from South African organisations and from a South African HEI in order to examine the research problem in more detail (Chapter 3). In addition, a survey of modellers from various organisations was undertaken in order to empirically validate the theoretical model (Chapter 3). The results from both the pilot study and the survey were used to contribute to defining the objectives of a CBPM touch solution and to clarify the aspects of CBPM (Chapter 4).

Chapter 4 investigated several technologies for CBPM and the tablet PC was selected as the hardware to be used for the BPMTouch software application. The objectives of the BPMTouch software tool were proposed, as well as the functional and non-functional requirements.

This chapter addresses the design and development activity in DSR (Section 1.10.2) and therefore meets research objective five; *"Identify the usability criteria and design considerations of current CBPM tools".* This chapter documents and describes the evaluation plan for two evaluations, the field study of EA and the final BPMTouch evaluation, which includes the research materials, usability metrics and the results of the field study (Section 5.2). The requirements also need to be analysed and the design of a CBPM solution described. Before the design could be finalised, a further, more in-depth field study of existing BPM software tools was undertaken to ensure that these tools could not satisfy the requirements.

The results of the field study will be analysed and taken into consideration for the design of the BPMTouch software tool (Section 5.3). This will answer *RQ5: "What are the usability*

criteria and design considerations of current CBPM tools?" and satisfy *RO₅*: *"Identify the usability criteria and design considerations of current CBPM tools"*. ProcessCraft, a BPM software application available on Google Play will then be discussed in Section 5.4 along with the design and development of the BPMTouch software tool. The chapter will be summarised in Section 5.5. The chapter layout is shown in Figure 5.1.
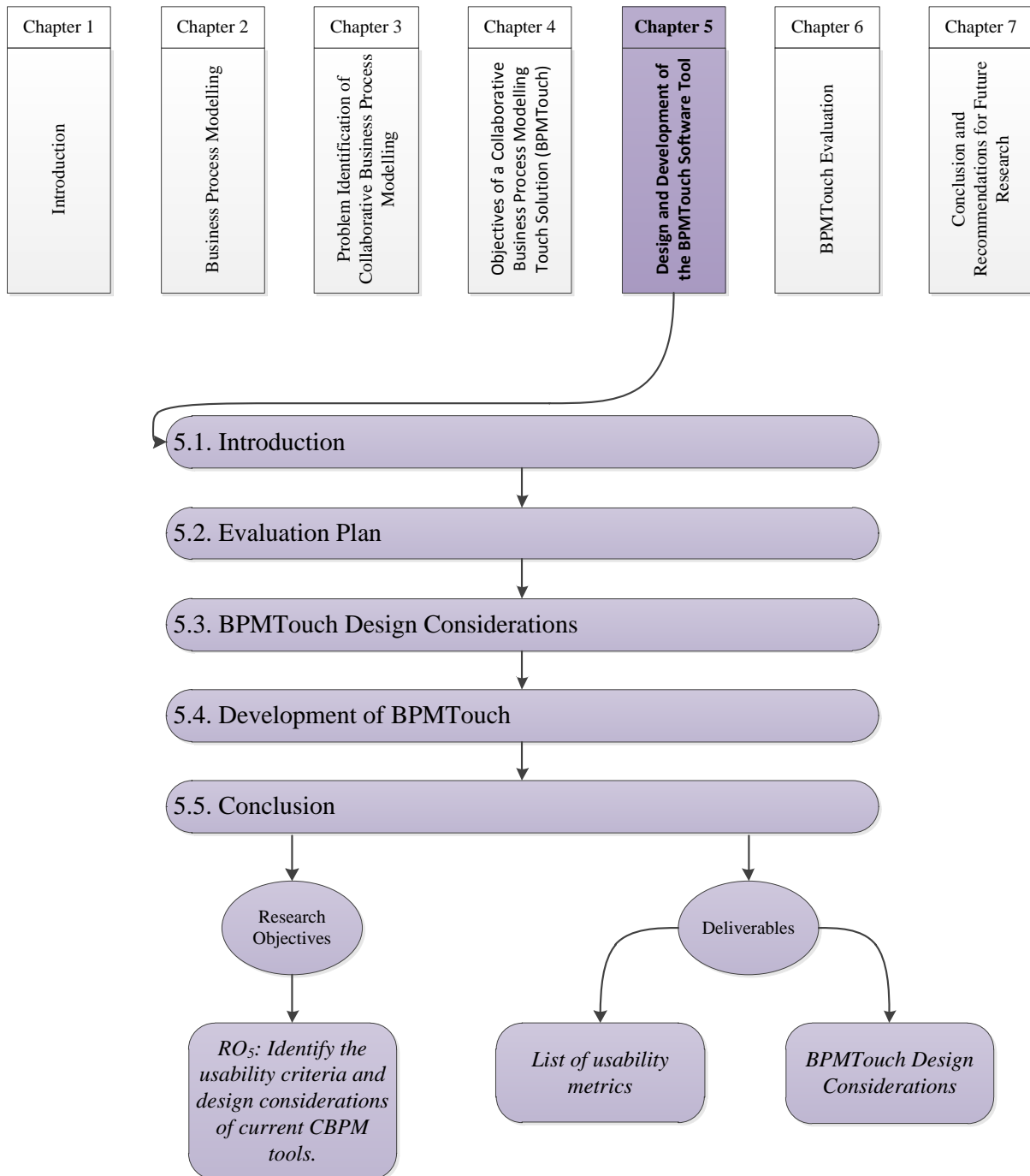
Figure 5.1: Chapter 5 layout

5.2. Evaluation Plan

The objectives and high-level requirements of a CBPM systems were identified (Section 4.3). The next step is to design and develop an artifact that can solve the problems identified. However, in order to design such an artifact it is necessary to investigate existing systems in more detail so as to determine if they can provide a solution, and in order to identify the positive aspects and problems of the system. These issues can then be used as design considerations to be taken into account in the design of the final artifact. For this reason an evaluation plan was designed for a preliminary evaluation of an existing BPM system (EA) as well as for the evaluation of the final artifact (BPMTouch). This evaluation plan lists the research materials (Section 5.2.1) and data analysis techniques which were used for the field study of the traditional BPM software (Section 5.2.2), EA as well as for the evaluation of the final BPMTouch software tool. Evaluation metrics will be used as measures to evaluate the artifact (Section 5.2.3). The preliminary field study took place in a BPM course where EA was used (Section 5.2.4). The reliability and validity of the questionnaire as well as the results are also discussed.

5.2.1. Research Instruments

Several problems relating to the challenges of CBPM tools have been identified in literature (Chapters 2 and 3) and in the pilot study of EA. However, the pilot study (Section 3.4) did not specify or enforce the method in which the modellers had to collaborate. The focus and problem of this study is on more than one modeller working on the same model synchronously in a co-located environment. Therefore, additional studies were required to evaluate how small teams of modellers collaborate when required to work on the same model synchronously.

Table 5.1 shows the research instruments that will be used in the field study and the BPMTouch usability evaluation. An identifier is assigned to each research material in order to identify the specific material. The material description describes the research instrument and the evaluation column indicates in which evaluation the instrument will be used. The data analysis of each research material is shown as well as the type of data that will be collected. The identifiers, demographics (D_1 and D_2), instructions (I_1), tasks (T_1 and T_2) and post-test questionnaires (PT_1 and PT_2) are shown in the identifier column (Table 5.1).

Table 5.1: Research instruments used

Identifier	Material Description	Evaluation	Data Analysis	Type Classification
D_1	Consent form	Field study BPMTouch evaluation	No analysis	Demographic
D_2	Biographical questionnaire	BPMTouch evaluation	Quantitative statistical analysis (frequency)	
I_1	Written information given to participants	Field study BPMTouch evaluation	No analysis	Instructions
T_1	Task list – field study	Field study		
T_2	Task list – BPMTouch evaluation	BPMTouch evaluation		
PT_1	Post-test questionnaire	Field study	Qualitative thematic analysis Quantitative statistical analysis (frequency, mean, Cronbach's alpha)	Evaluation
PT_2	Post-test questionnaire	BPMTouch evaluation	Qualitative thematic analysis Quantitative statistical analysis (frequency, mean, Cronbach's alpha)	

Participants were required to complete a consent form (D_1: Appendix C) for the field study evaluation and the BPMTouch evaluation. BPMTouch evaluation participants were also required to complete a biographical questionnaire (D_2: Appendix A). Participants were also supplied with written information (I_1: Appendix D) about the study. Upon completion of the evaluations, participants must fill in a post-test questionnaire. Figure 5.2 visualises the model of the study which incorporates the research instruments used for the field study and the BPMTouch usability evaluation.
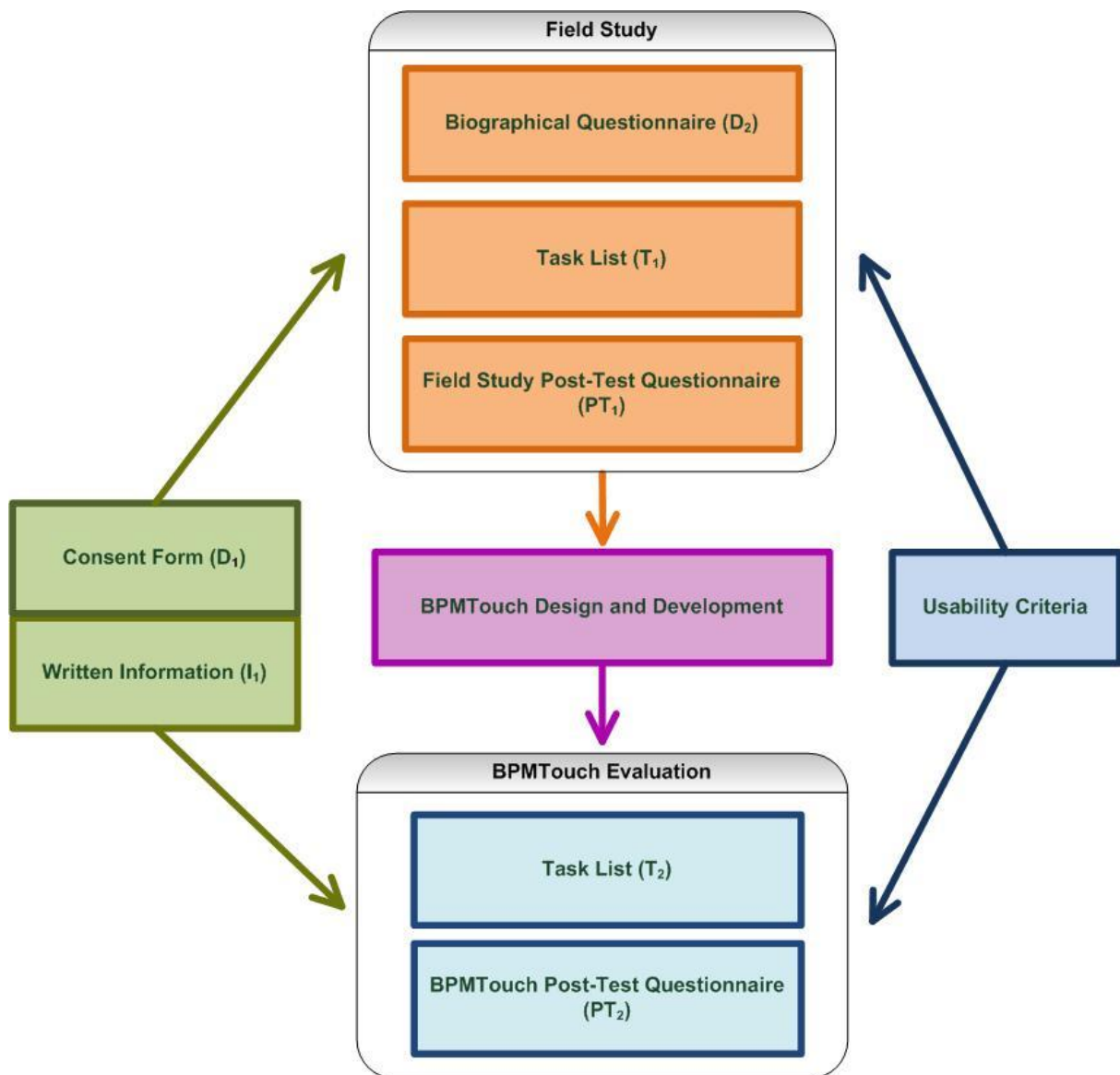
Figure 5.2: Evaluation model and research instruments

The face validity of the questionnaires was established by only using questions from literature sources or previous studies such as the pilot study (Section 3.4) and the survey for CBPM (Section 3.5). The content validity of the questionnaires was verified by means of a pilot study in which the participants did not change anything in the questionnaires. The reliability was determined by using Cronbach's alpha value calculations and all of the values were of an acceptable standard.

As part of the qualitative analysis, a check on the reliability for all of the questionnaire responses (Section 5.2.2) was carried out constantly by following Gibbs' (2007) procedures. The completed questionnaires were reviewed several times by the researcher to ensure that there were no errors, the codes were continuously compared to make sure that the code meanings did not change and a different researcher examined the codes. Validity was also ensured by describing the findings as thoroughly as possible, avoiding and removing any possible bias and noting negative behaviour (Creswell 2009).

5.2.2. Qualitative Data Analysis Techniques

Thematic analysis will be used to analyse the qualitative data captured in the questionnaires. Thematic analysis incorporates recognising and analysing themes and reporting on the themes found within the data. Creswell's (2009) data analysis procedure for qualitative research (Figure 5.3) will be followed in order to become familiar with the data, the analysis and identifying themes.

The data analysis procedure (Figure 5.3) starts at the bottom and comprises the following steps:

Step one: Organising and preparing the data for analysis. The data will be obtained from web-based questionnaires. Therefore, the results have already been captured and the responses will be in column form.

Step two: Review all of the data so that the examiner is familiar with the information and can form a general impression of the data.

Step three: Use a coding process to organise the data into different categories. The different codes should be created according to readers' expectations, but not what they anticipate. It should be unusual and provide a bigger perspective.

The coding process can be carried out by hand or by the use of a software program.

Step four: Identify themes or descriptions from the categories. Themes will be used in this study as descriptions are mainly used to describe people and places involved. The themes will represent the results from the questionnaires.

Step five: The themes should be represented in an appropriate manner, by making use of, for example, a passage to discuss and display the findings from the questionnaire in the form of a discussion of several themes.

Step six: Deduce "lessons learnt" from the data and themes to provide more meaning to the information. The interpretation can be a comparison with literature to deny or confirm the ideas or it can be a personal interpretation.
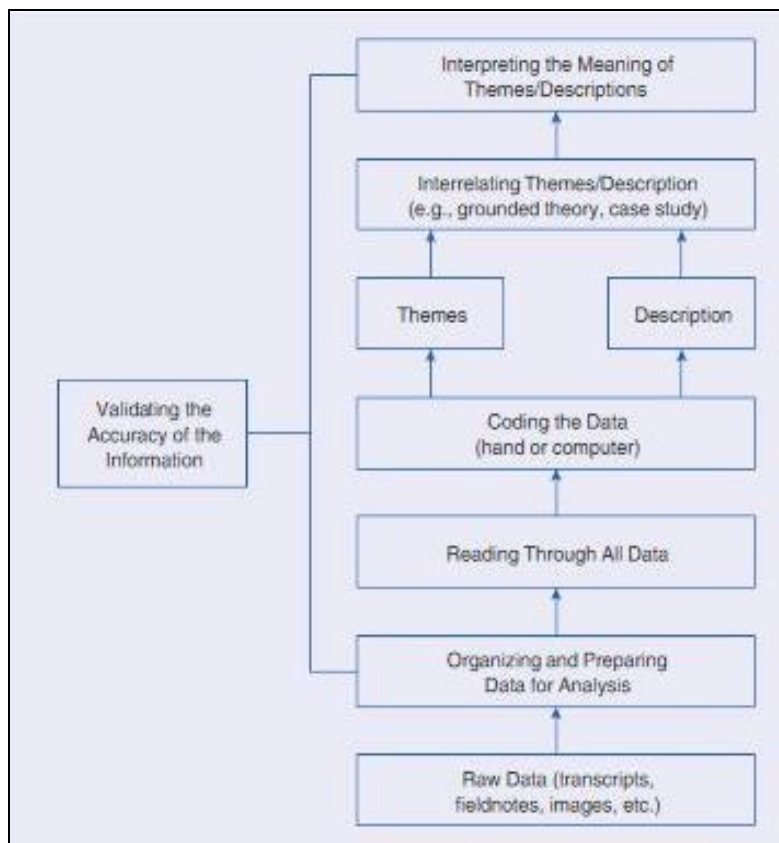
Figure 5.3: Data analysis procedure for qualitative research (Creswell 2009)

The results have to be validated to ensure that they are accurate and credible (Creswell 2009). Validity pertains to confirming that the qualitative results are accurate by using a specific process. Gibbs (2007) proposed several reliability procedures and these include:

- Review the transcripts and make sure that there are no errors;
- Compare the codes continuously to ensure that there is no change in the code meanings; and
- Ask a different researcher to examine the codes.

Validity can also be ensured by following one or more of these strategies:

- Member Checking: The final analysed results from the surveys and questionnaires could be given to the participants to determine how accurate the results are;
- Triangulation: Triangulation refers to using different sources of information in order to motivate the identified themes;
- A Rich Description of the Findings: The findings should be documented in a descriptive way so that the reader experiences the situation;
- Possible Bias: Any bias provided in the study should be identified and noted in order to justify the accuracy of the results and findings; and
- Noting Negative Behaviour: Any findings that contradict the main themes of the questionnaire results should be discussed.

Qualitative and quantitative results will be captured and analysed. The qualitative results will be used to confirm quantitative results.

5.2.3. Evaluation Metrics

The first step in an evaluation plan is to define metrics for the evaluation. In order to evaluate the usability of the BPM software tools, metrics of usability which will be measured need to be identified. Quality in use is defined by the degree to which a software product meets the users' needs to achieve predefined goals with effectiveness, efficiency, flexibility, safety and satisfaction in a specified environment of use (ISO 2008).

Quality in Use Integrated Map (QUIM) factors are quality in use factors which are a user-oriented characteristic of the interface (Donyaee 2001) and include effectiveness, efficiency and satisfaction. Software quality refers to the degree to which the software satisfies a predefined need "when used under specified conditions" (ISO 2008, p. 9).

ISO defines usability (operability) as " the degree to which the software product can be understood, learned, used and is attractive to the user, when used under specified conditions " (ISO 2008). Nielsen (1993) proposes that usability comprises several components which are made up of usability metrics, such as learnability, memorability, errors, efficiency and satisfaction.

The term "usability" has been replaced in the ISO 25010 by "operability" (ISO 2008, p. 16). Operability refers to the ability of the software to allow users to operate and control it (ISO 2000; Donyaee 2001). For the purpose of this study, the term usability will be used. Criteria refers to sub-factors of the user interface and they are generally more challenging to grasp by the user (Donyaee 2001). The three most commonly used usability metrics are effectiveness, efficiency and satisfaction.

*Effectiveness***:** Effectiveness is the ability of the software to allow the users to accurately complete specific tasks (Seffah *et al.* 2006). *Completeness* can be considered as a similar concept to effectiveness as it is the degree to which users can accomplish a specific task (Donyaee 2001).

*Efficiency***:** Efficiency refers to the degree to which the product performs as expected by the users so that they can accomplish their tasks successfully (Rubin and Chisnell 2008). The system should be efficient enough so that users can be highly productive after learning to use the system (Nielsen 1993). A good way to measure efficiency is to identify expert users, define expertise and measure the amount of time it takes the expert users to carry out the tasks. Efficiency refers to the capability of the software to allow users to utilise appropriate amounts of resources relative to the effectiveness achieved (Seffah *et al.* 2006). Efficiency is also how quickly a user's goals can be accurately and completely achieved (Rubin and Chisnell 2008).

*Satisfaction***:** The system should be satisfying to use (Nielsen 1993). Subjective satisfaction can be measured by asking users to complete questions about their satisfaction. Initially the result will be subjective but as soon as several results are combined and the results are averaged, it becomes an objective measure of satisfaction. Satisfaction was also identified as an usability attribute by Seffah *et al.* (2006), Rubin and Chisnell (2008) and Sauro (2011).

Other usability metrics cited in software evaluations are ease of use, learnability, attractiveness, understandability, errors and accuracy (Nielsen 1993; ISO 2000; Donyaee 2001; Seffah *et al.* 2006; ISO 2008; Rubin and Chisnell 2008; Sauro 2011).

***Ease of use*:** Ease of use refers to the extent that the software makes it easy for users to use and control the software (ISO 2008). Ease of use also refers to measuring the user's effort for operation (Donyaee 2001).

***Learnability*:** Users should be able to learn how to use the system easily so that they can start working on the system (Nielsen 1993). In the majority of cases, learnability is an essential usability attribute as the first thing users do when using a system is learn how to use it. Learnability also refers to the extent that the software enables users to learn the application (ISO 2008) and their ability to operate the software after learning to use it (Rubin and Chisnell 2008). Learnability is the part of the software that allows users to quickly feel productive using the system after which they can quickly learn new functionality (Seffah *et al.* 2006).

***Attractiveness*:** Attractiveness refers to the degree to which the user finds the software attractive (ISO 2000, 2008) and likeable throughout the operation (Donyaee 2001).

***Understandability*:** Understandability refers to the ability of the software to enable users to determine whether the software is appropriate and how it can be used (ISO 2000). Understandability also refers to measuring how difficult a user finds the software to understand without any prior knowledge of the software (Donyaee 2001). Understandability refers to the extent to which the users recognise that the software can fulfil their needs (ISO 2008).

***Errors*:** Users should not be able to make errors easily while using the system and they must be able to recover quickly if errors are made (Nielsen 1993). The system should not allow for any disastrous errors to take place. An error is an action that does not accomplish a predefined goal and users should make minimal errors when using the system. Different errors exist; some are easily corrected as soon as they occur, others can slow down the user's productivity and catastrophic errors can lead to the destruction of the user's work. Errors were identified as an usability metric by (Nielsen 1993; Sauro 2011).

***Accuracy*:** Indicators that gauge whether correct or agreed-upon results or effects have been provisioned (Donyaee 2001). Accuracy also refers to the extent to which the software provides the correct results to a specific degree of precision (ISO 2008).

The Post-Study System Usability Questionnaire (PSSUQ) is a 19 item questionnaire that evaluates the user satisfaction and usability of a system (Lewis 1995). The PSSUQ requires users to rate usability statements on a 7-point Likert scale.

This section identified possible usability metrics that can be used for a usability evaluation. Efficiency, effectiveness and satisfaction are the main usability metrics and also form part of the thesis statement (Section 1.4): ***A framework for co-located collaborative business process modelling (CBPM) using touch technologies can improve the efficiency, effectiveness and user satisfaction of business process modelling activities.***

5.2.4. Field Study of Extant Systems [4]

A field study was carried out with second year university students in order to evaluate the usability of EA for CBPM. An overview of the field study is provided which discusses the participant profile (Section 5.2.4.1) and the research instruments are discussed in Section 5.2.4.2. The reliability and validity of the results are discussed (Section 5.2.4.3) and results of the field study have been analysed and documented (Section 5.2.4.4).

5.2.4.1. Overview of the Field Study

The Department of Computing Sciences at NMMU offers a second year WRBP201 (BPM) module. A field study with two assignments in this module was carried out and the resulting participant profile was made up of 37 BPM students, of which 26 were males and 11 were females. In both of the assignments the participants were provided with a post-test questionnaire comprising 12 Sections (S1 to S12) which they were required to complete. In the first assignment, only 26 students completed the questionnaire, whereas in the second assignment 35 students completed the questionnaire. The two assignments were carried out in the students' practical sessions. Each student had to pair up with a partner and draw a BPMN model in EA. EA was chosen as a possible solution to CBPM and represents a traditional BPM solution. The purpose of the study was to identify how students would combine their

---

[4] A paper "The Usability of Collaborative Tools: Application to Business Process Modelling Tools" won runner up best paper at SAICSIT 2013, based on this section of the study (Appendix T).

separate parts of the model drawn in EA and how difficult it was to combine and synchronise the model. Other goals were to determine the usability of EA, the positive and negative features of how EA works as a BPM tool and how the CBPM aspects assisted or hindered the students.

5.2.4.2. Research Instruments for the Field Study

Before the practical sessions, students had been attending lectures in which they were introduced to BPM and the concept of BPMN. During the field study, participants were supplied with the tasks of the BPM activity (T_1: Appendix L) and the scenarios (Appendix K and M) for assignments one and two respectively, which they had to model in EA. Upon completion of the activity, participants were required to complete the post-test questionnaire (PT_1: Appendix N). The questionnaire consisted of several questions that the participants had to answer by rating the answers on a 5-point Likert scale with 1 representing *Strongly Disagree* and 5 representing *Strongly Agree*.

Section 1 of the questionnaire required participants to indicate whether they were able to complete the task successfully. Section 2 focussed on BPM and included statements such as: "*You are satisfied with your task time*", "*you are satisfied with your overall model*", "*you made a minimal number of errors*", "*you were able to create a model using the EA tool*", "*you experienced minimal usability problems with the modelling tool*" and "*modelling the process using EA is an easy task*". The metrics used for the BPM usability section (S2) include errors, efficiency, modeller satisfaction, effectiveness and ease of use (Table 5.2). Items Q2-1 and Q2-4 are a subjective measure of the "errors" usability criteria. Item Q 2-2 is a partial subjective measure of efficiency, item Q2-3 is a subjective measure of satisfaction, Q2-5 is a subjective measure of effectiveness and Q2-6 is a subjective measure of ease of use.

Table 5.2: BPM usability section (S2) of the questionnaire

Question Number	Question	Metric	Reference
Q2-1	You experienced minimal usability problems with the modelling tool.	Errors	Nielsen (1993) BPM Pilot Study
Q2-2	You are satisfied with your task time.	Efficiency	Nielsen (1993)
Q2-3	You are satisfied with your overall model.	Modeller Satisfaction	Bandara *et al.* (2005) BPM Pilot Study
Q2-4	You made a minimal number of errors.	Errors	Nielsen (1993) BPM Pilot Study
Q2-5	You were able to create a model using the Enterprise Architect tool.	Effectiveness	Sparx Systems (2013b) Seffah *et al.* (2006)
Q2-6	Modelling the process using Enterprise Architect is an easy task.	Ease of use	Sparx Systems (2013b) ISO (2008)

Section 3 (S3) focussed on collaboration (Table 5.3). The statements, "*I was able to collaborate easily*", "*working collaboratively using this system was not challenging*", "*I can easily share ideas using this system*" and "*I was able to easily communicate with my team members*" were adopted from (Snyman 2011) while the rest were added by the author. The metric used for S3 is collaboration. In this way the overall response to collaboration is measured instead of individual attributes.

Table 5.3: Collaboration section (S3) of the questionnaire

Question Number	Question	Reference
Q3-1	All the team members participated in the modelling process.	BPM Pilot Study
Q3-2	Minimal mistakes were made due to collaborating with other team members.	
Q3-3	My experience with collaborative business process modelling in this exercise has been positive.	
Q3-4	I was able to collaborate easily.	Snyman (2011)
Q3-5	Having a partner made the task of modelling easier.	BPM Pilot Study
Q3-6	Working collaboratively using this system was not challenging.	Snyman (2011)
Q3-7	I can easily share ideas using this system.	
Q3-8	I was able to easily communicate with my team member(s).	

Section 4 (S4) of the questionnaire is the PSSUQ which is a 19 item questionnaire designed to evaluate a user's satisfaction with a specific computer system (Lewis 1995). The original PSSUQ was an 18-item (version one) questionnaire (Lewis 1992). This questionnaire was then changed based on the work of Doug Antonelli who revealed five system characteristics and the questionnaire only addressed four of the characteristics (Lewis 1995). The 19-item PSSUQ (version two) addresses all five characteristics. After many years, item analysis showed that three of the 19 questions do not contribute enough to the reliability of the PSSUQ and these were removed to create the third version of the PSSUQ (Sauro and Lewis 2012). Version two of the PSSUQ is however used for this study. The PSSUQ uses a 7-point Likert scale, however, the PSSUQ only forms part of the post-test questionnaire and the consulted statistician agreed that a 5-point Likert scale will suffice. Four scores can be calculated from the PSSUQ and are calculated by averaging the responses from the participants (Table 5.4). The four scores are:

- The overall satisfaction score (OVERALL);
- System usefulness (SYSUSE);
- Information quality (INFOQUAL); and
- Interface quality (INTERQUAL).

The metrics that form part of SYSUSE are ease of use, learnability, speed and accomplishment. INFOQUAL comprises adequacy and understandability (Keinonen 1998). There is only one metric, affect for INTERQUAL.

Section 5 focussed on the approaches to CBPM and included statements that asked the participants how they went about collaborating while carrying out their tasks. Section 6 listed possible challenges that the participants might have had while carrying out the task. These statements were all identified in the results pilot study of CBPM (Section 3.3). Section 7 refers to the positive aspects of CBPM and these statements are based on literature (Section 3.2).

Table 5.4: Usability section (S4) of the questionnaire – PSSUQ (Lewis 1995)

Question Number	Question	Metric
Q4-1	Overall, I am satisfied with how easy it is to use the system (EA).	SYSUSE
Q4-2	It was simple to use the system.	
Q4-3	I could effectively complete the tasks and scenarios using this system.	
Q4-4	I was able to complete the tasks and scenarios quickly using this system.	
Q4-5	I was able to efficiently complete the tasks and scenarios using this system.	
Q4-6	I felt comfortable using this system.	
Q4-7	It was easy to learn to use this system.	
Q4-8	I believe I could become productive quickly using this system.	
Q4-9	The system gave error messages that clearly told me how to fix problems.	INFOQUAL
Q4-10	Whenever I made a mistake using the system, I could recover easily and quickly.	
Q4-11	The information (such as on-line help, on-screen messages and other documentation) provided with this system was clear.	
Q4-12	It was easy to find the information I needed.	
Q4-13	The information provided for the system was easy to understand.	
Q4-14	The information was effective in helping me complete tasks and scenarios.	
Q4-15	The organisation of information on the system was clear.	
Q4-16	The interface of was this system was pleasant.	INTERQUAL
Q4-17	I liked using the interface of this system.	
Q4-18	This system has all the functions and capabilities I expect it to have.	
Q4-19	Overall, I am satisfied with this system.	SYSUSE

5.2.4.3. Reliability and Validity of Field Study Research Instruments

A pilot study was carried out with two pairs of participants (n = 4) in order to ensure that the questionnaire and task list was unambiguous. No problems were identified during the pilot study. Item reliability for the questionnaires was established as the various sections on BPM (S2), Collaboration (S3), Usability (S4), Challenges (S6) and Positive Aspects of CBPM (S7) all have Cronbach's alpha values higher than 0.7 (Appendix O). A Cronbach's alpha value greater than 0.7 is an acceptable industry standard (Nunnally 1978) which indicates reliability consistency of the questions and replies to the questions. Section 5 on Approaches to CBPM, scored a Cronbach's alpha value of 0.59 and 0.62 for assignment one and two respectively which is below the accepted industry standard, but since this is an initial study, the results are acceptable for this study (Nunnally 1978).

Cronbach's alpha was calculated for each section of the questionnaire where it was relevant (Appendix O). Cronbach's alpha indicates reliability and consistency and a value of 0.70 or higher is acceptable (Nunnally 1978; Institute for Digital Research and Education 2013). The BPM section had a Cronbach's alpha value of 0.83 for assignment one and 0.79 for assignment two, which indicates that the questions in the section and the responses received are consistent. The Cronbach's alpha value for the collaboration section is 0.84 for assignment one and 0.82 for assignment two which are acceptable values. The Cronbach's alpha for the usability section of the questionnaire for assignment one is 0.94 and 0.95 for assignment two (Appendix O). These values are significantly higher than the accepted Cronbach's alpha standard of 0.7 which indicates that the questions and responses to questions in this section are very consistent. The overall result indicates that the system (EA) is usable.

The section on approaches to CBPM in the questionnaire has a Cronbach's alpha value of 0.59 for assignment one and 0.62 for assignment two (Appendix O). This value is below the accepted Cronbach's alpha value of 0.7. In both cases, if Q5_1 "*One person operated EA and the other person provided input*" is disregarded, Cronbach's alpha becomes 0.73 which is an acceptable value. The Cronbach's alpha value for the challenges section is 0.8 for assignment one and 0.87 for assignment two (Appendix O) which shows that all of the challenges identified as well as the responses supplied by participants were consistent. Lastly, the section, positive aspects of CBPM has a Cronbach's alpha value of 0.92 for assignment one

and 0.93 for assignment two which are also acceptable values. The qualitative results will be used to confirm the quantitative results.

5.2.4.4. Field Study Results

Each participant was required to model a part of the model separately (Figure 5.4 and Figure 5.5) before combining the separate models (Figure 5.6). Figure 5.4 shows participant 8A's model in which the participant only modelled the Clerk lane. Figure 5.5 shows the rest of the model which was modelled by participant 8B and this includes the Logistics Manager and Warehouse Worker lanes. Figure 5.6 shows a combined model in which the model from 8A and the model from 8B have been integrated into one model. The blue elements were drawn by participant 8A and the green elements were drawn by participant 8B. Participants 8A and 8B's models were selected for demonstration based on a random selection.

The easiest way for participants to combine the two models was to use the built-in import/export function of EA. EA has a built-in import and export function which allows users to save their models in XML and export or import it via XMI it into a different solution (Payton 2007). In assignment one, 16 participants combined their models by using the import and export function and in assignment two, 24 participants used the import and export function in EA. Participants stated that they experienced great difficulty in using the import and export function and aligning the objects in the two models. For example, participant 8A saved his/her model and then exported the XMI file to a flash drive. The flash drive was then given to participant 8B who imported the exported XMI file into his/her solution. The second modeller in the team was then able to copy the work from 8A's solution into 8B's solution in order to create a combined solution. In both of the assignments all the participants (100%) indicated that they successfully completed their tasks.
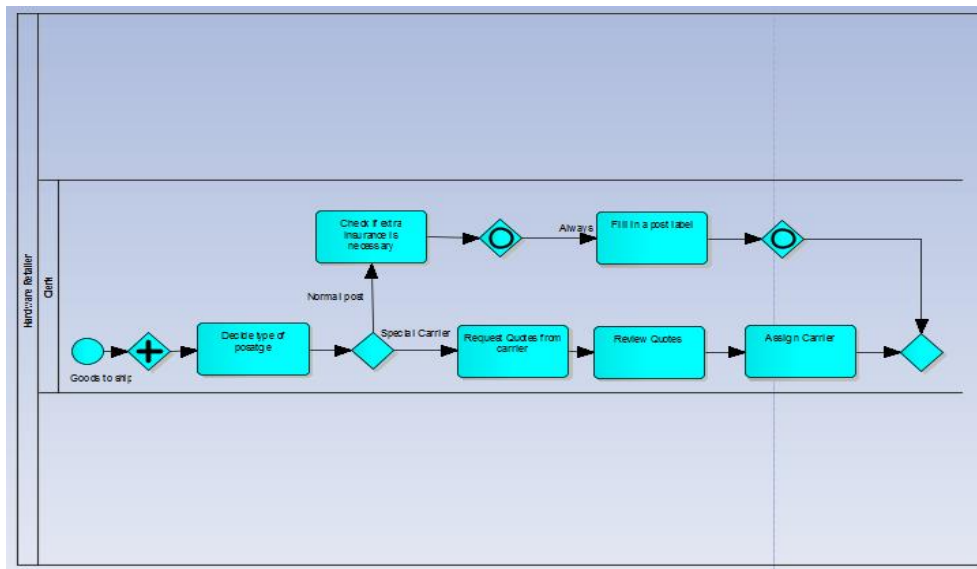
Figure 5.4: Model by participant 8A
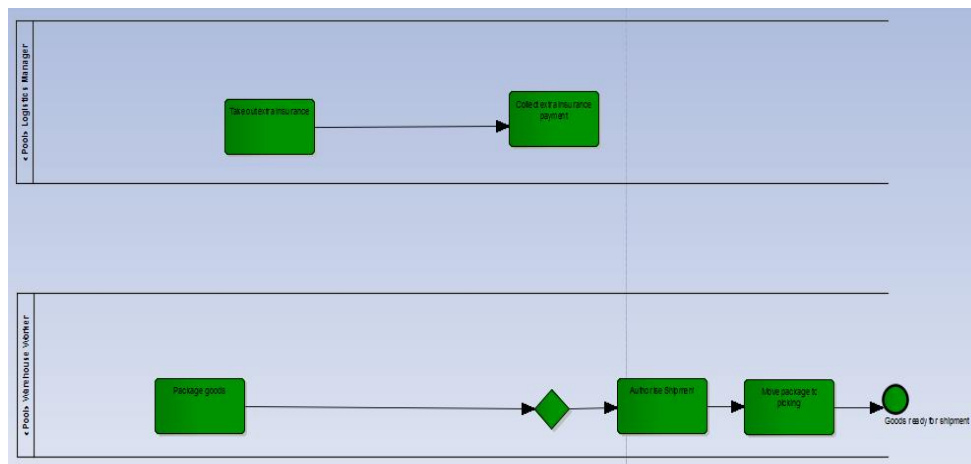
Figure 5.5: Model by participant 8B
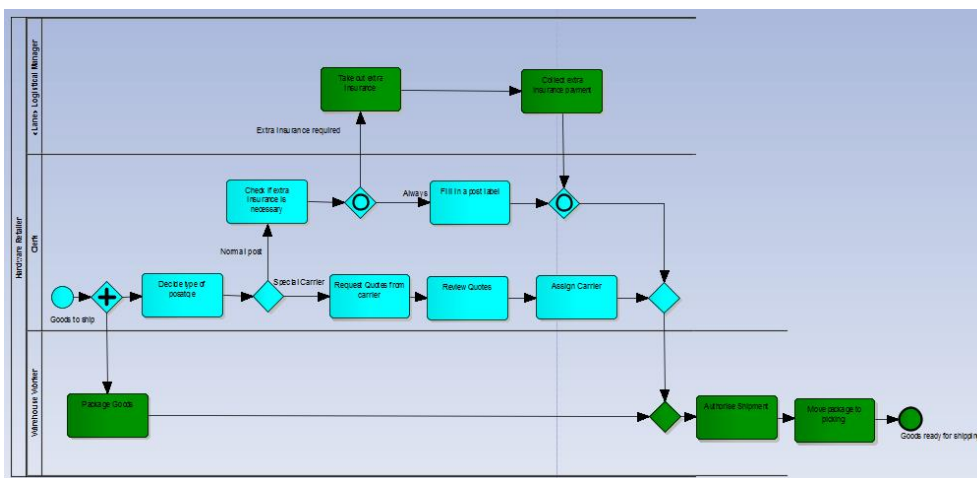
Figure 5.6: Combined model by participants 8A and 8B

The overall mean value for the BPM usability section (S2) of the questionnaire for assignment one is larger than 3 ($\mu = 3.41$) which is a *positive* rating and for assignment two is higher than four ($\mu = 4.04$) which is also a *positive* rating. In both assignments (Figure 5.7) participants agreed that they were able to create a model using EA since both mean ratings were *positive* ($4.30 \leq \mu \leq 4.60$) for assignment one and two respectively.

The lowest mean score for assignment one ($\mu = 2.89$) is for "Y*ou experienced minimal usability problems with the modelling tool*". This rating is *neutral* on the 5-point Likert scale which indicates that participants experienced some usability problems with the modelling tool. This value increased in the second assignment. The lowest mean score for the second assignment ($\mu = 3.60$) is for *"You experienced minimal usability problems with the modelling tool"*. This score is above three and indicates that participants gave a *positive* rating to whether experienced minimal usability problems with EA. The overall mean score for "*You made a minimal number of errors*" for assignments one ($\mu = 3.48$) and two ($\mu = 3.77$) is a *positive* rating. The ease of use of EA ranges between a *neutral* and *positive* rating with the mean value of assignment one ($\mu = 3.19$) and two ($\mu = 3.69$) both higher than three. All of the mean scores except for one in the BPM usability section scored *positive* ratings. Participants gave higher scores for every statement in S2 for the second assignment. This could possibly be due to a learning effect (Rafi *et al.* 2012).

Efficiency (Table 5.2) is subjectively measured by "*Satisfied with task time*". The task time received a *neutral* rating for assignment one ($\mu = 3.04$) and a *positive* rating for assignment two ($\mu = 4.00$). The reason for this could be that the students overcame the learning curve of EA from assignment one to two. This means that EA is efficient as users can be productive after learning how to use the system (Nielsen 1993) and they are satisfied with their task times (Rubin and Chisnell 2008) in assignment two.

Satisfaction (Table 5.2) is partially subjectively measured by "*Satisfied with model*". The mean values for assignment one ($\mu = 3.59$) and assignment two ($\mu = 4.57$) are both *positive* ratings. These results show that participants found EA satisfying to use (Nielsen 1993; Rubin and Chisnell 2008; Seffah *et al.* 2006; Sauro 2011).

Effectiveness (Table 5.2) is subjectively measured by item "*Able to create a model with EA*". The mean score is in the *positive* range for both assignments ($4.30 \leq \mu \leq 4.60$), therefore, EA

is effective as it allowed the participants to complete a specific task. This result supports that models can be created in EA (Payton 2007).

Ease of use (Table 5.2) is subjectively measured by "*Modelling using EA is easy*". The mean scores for both assignments are greater than three ($3.19 \leq \mu \leq 3.69$) which is a positive rating. Therefore, based on the definition of ease of use (ISO 2008), the result indicates that EA is easy to use .
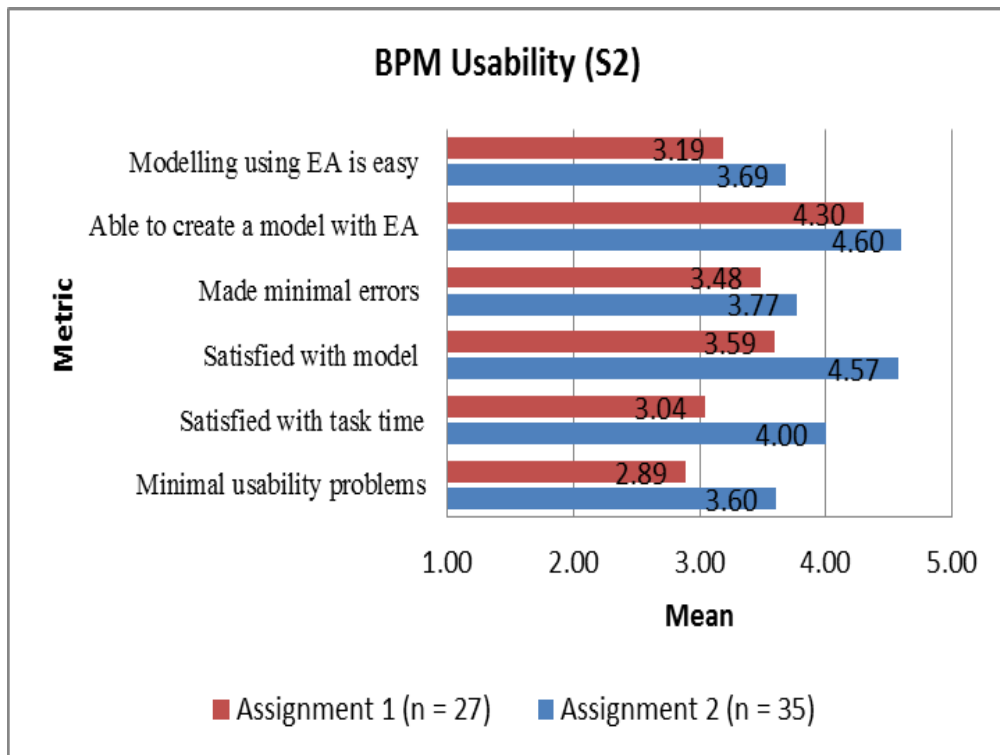
Figure 5.7: BPM Usability (S2)

The overall mean value of the collaboration section (S3) (Figure 5.8) is higher than three for assignment one ($\mu = 3.84$) and higher than four for assignment two ($\mu = 4.19$). The highest mean score for assignment one ($\mu = 4.59$) and two ($\mu = 4.77$) is for *"All members in the team participated"*. All of the mean scores are above three ($3.37 \leq \mu \leq 4.77$) indicating that participants were between *neutral* and *positive* for all of the collaboration statements.
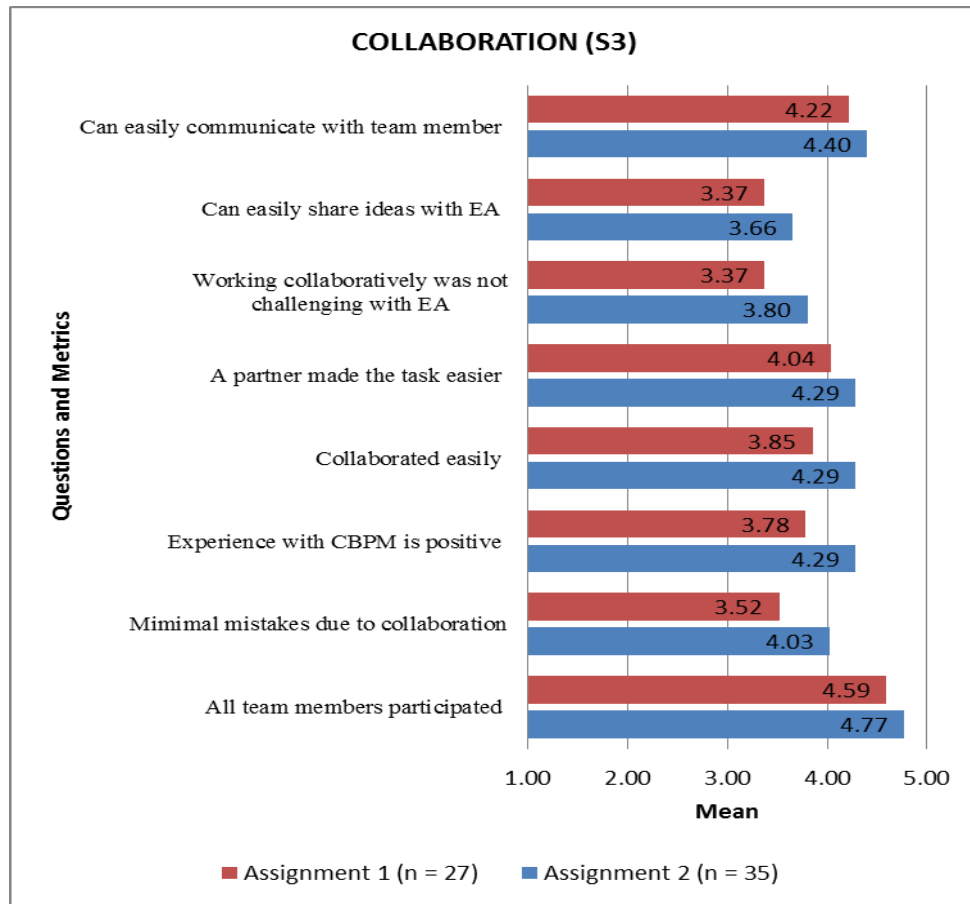
Figure 5.8: Collaboration (S3)

The PSSUQ was used for usability section (S4) of the questionnaire (Section 5.2.4.2). The OVERALL, SYSUSE, INFOQUAL and INTERQUAL scores for both assignments are between *neutral* and *positive* (Table 5.5).

Table 5.5: Rules for calculating PSSUQ scores (Lewis 1995; Lewis 2002)

Score Name	Average the Responses to:	Assignment One (μ)	Assignment Two (μ)
OVERALL	Items 1 - 19	3.38	3.66
SYSUSE	Items 1 – 8 and 19	3.49	3.85
INFOQUAL	Items 9 – 15	3.24	3.38
INTERQUAL	Items 16 - 18	3.41	3.70

The mean scores (Figure 5.9) for S4 range between two and five ($2.71 \leq \mu \leq 4.06$) which is between the *neutral* and *positive* range. These scores are slightly lower than previous sections of the questionnaire.

The lowest scores for assignment one ($\mu = 2.78$) and for assignment two ($\mu = 2.71$) are both for *"Clear error messages"* indicating that the system did not provide clear error messages that could help participants fix problems. The highest mean scores for both assignment one ($\mu = 3.81$) and two ($\mu = 4.06$) are for *"Complete tasks effectively"* which falls under the SYSUSE metric (Table 5.4). The mean scores increased in all cases from assignment one to assignment two which is to be expected due to the learnability effect (Rafi *et al.* 2012).
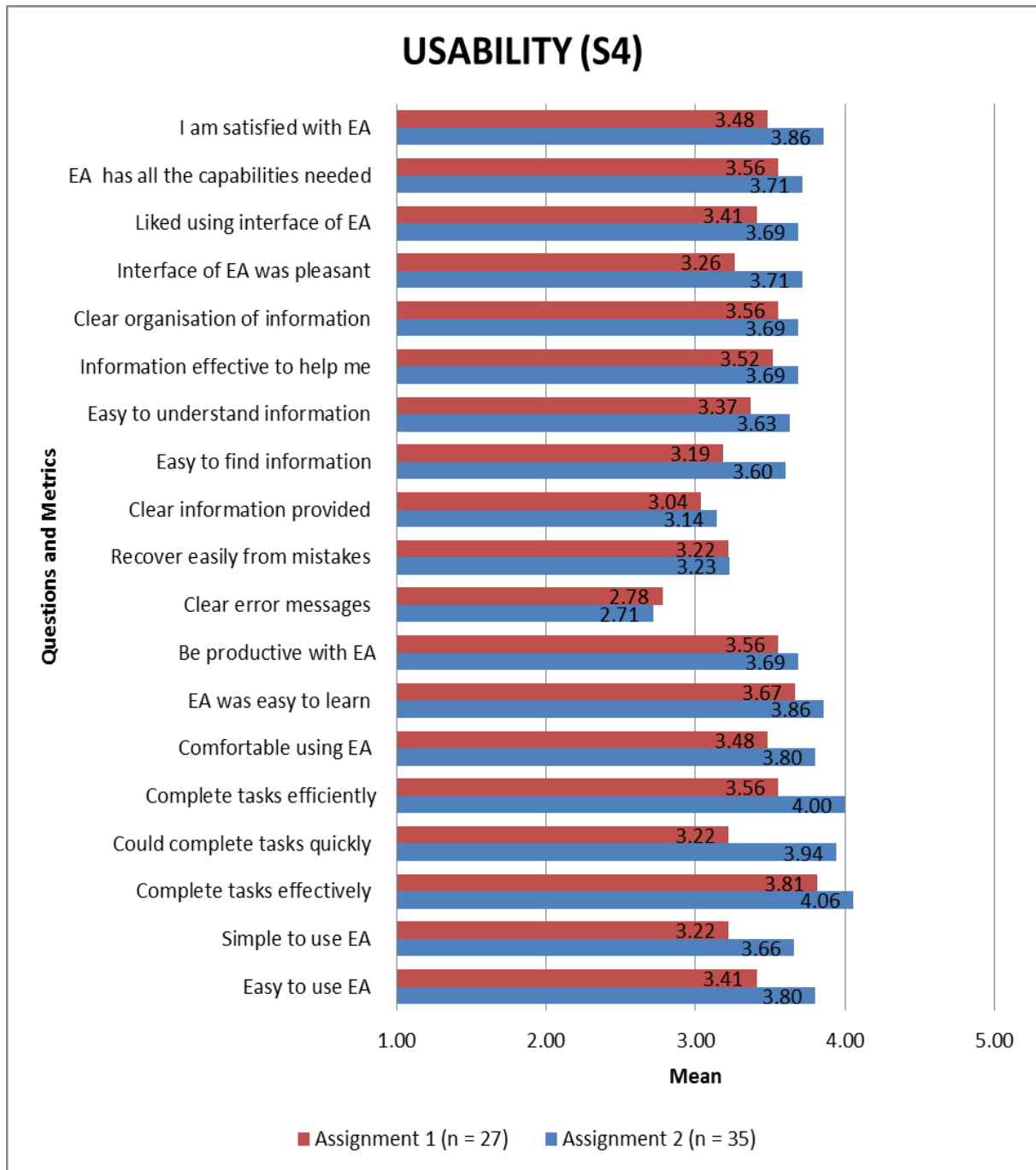
Figure 5.9: PSSUQ usability (S4)

109

All the mean scores (Figure 5.10) for the section on approaches to CBPM (S5) are below three except for one ($2.09 \leq \mu \leq 3.09$). This indicates that participants felt *neutral* towards the statements relating to the approaches to CBPM. The highest mean score ($\mu = 3.09$) is for the statement "*One operated EA, one provided input*", in assignment two, which indicates that participants might have used this type of collaboration approach while using EA. As the mean values are generally low, it could mean that participants followed different methods of CBPM.
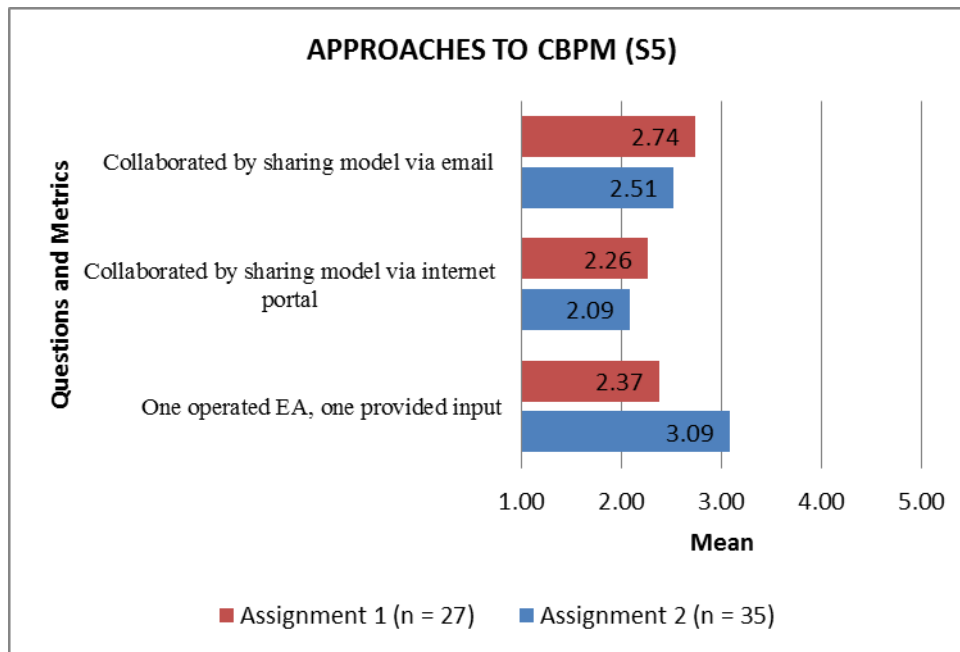
Figure 5.10: Approaches to CBPM (S5)

Similar to the approaches to CBPM, all of the mean scores ($2.29 \leq \mu \leq 2.81$) for the challenges section (S6) are below three (Figure 5.11) and is in the *negative* to *neutral* range. All of the ratings are *negative* except for "*Struggled to integrate models*" ($2.71 \leq \mu \leq 2.81$) in both assignments and "*Struggled to manage time, due to collaboration*" ($\mu = 2.81$) for assignment one. As most of the results are *negative*, it means that the participants did not agree with these challenges. "*Struggled to manage time due to EA*" and "*Struggled to integrate models*" does not confirm the results of the pilot study. "*Struggled to manage time due to collaboration*" does not confirm the study of Barjis (2011).
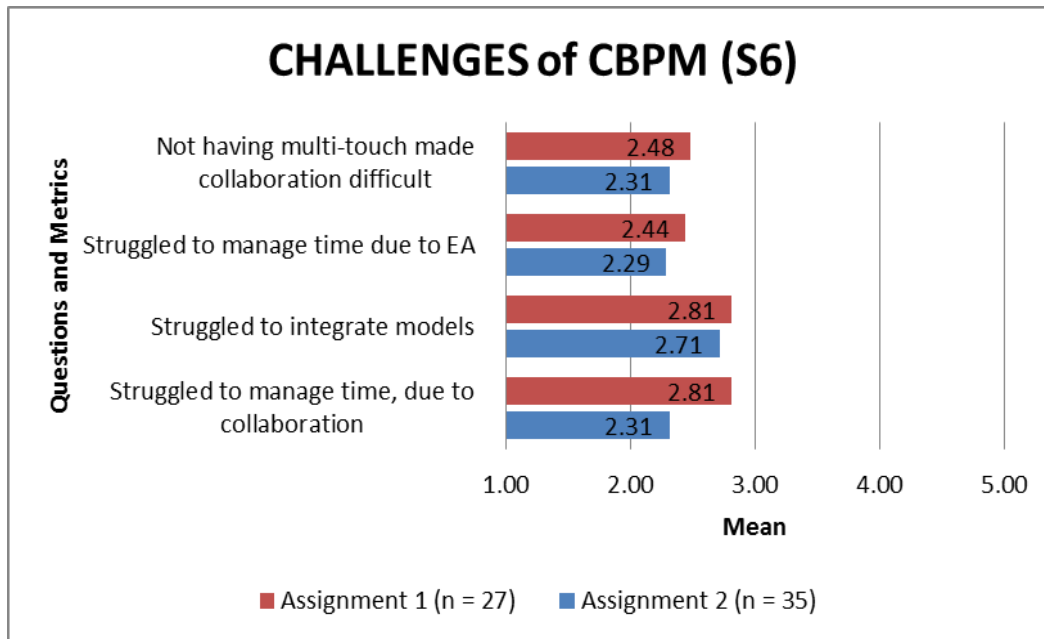
Figure 5.11: Challenges of CBPM (S6)

All of the mean scores except for two (Figure 5.12) are above four ($3.70 \leq \mu \leq 4.34$), for the positive aspects (benefits) of CBPM section (S7). This indicates that the results for this section are all in the *positive* range. The highest mean scores for both assignment one ($\mu = 4.22$) and two ($\mu = 4.34$) is for the statement "*Brainstorming amongst modellers*" which means that participants were *positive* that brainstorming amongst modellers is a benefit of CBPM. This result supports the study of Twinning *et al.* (2004) in which they stated that brainstorming is a benefit of collaboration. The overall results indicate that the participants were *positive* towards all of the benefits of CBPM which means that they agree with all of the benefits of CBPM.

"*Learning from other modellers*" ($4.15 \leq \mu \leq 4.26$) is therefore a benefit and this supports the study of Twinning *et al.* (2004) in which learning from others was identified as a benefit of CBPM. "*Sharing ideas, opinions and points of view*" ($4.19 \leq \mu \leq 4.29$) is a benefit which supports the results of the pilot study. "*Shared ownership*" ($4.04 \leq \mu \leq 4.17$) and "I*ncreased understanding amongst modellers*" ($3.70 \leq \mu \leq 4.14$) are benefits which confirm the study of Barjis (2009). "*Increased confidence amongst process users*" ($4.04 \leq \mu \leq 4.20$) and "*More accurate modelling due to collaboration*" ($3.81 \leq \mu \leq 4.14$) are benefits that confirm the study of Barjis (2011).

111
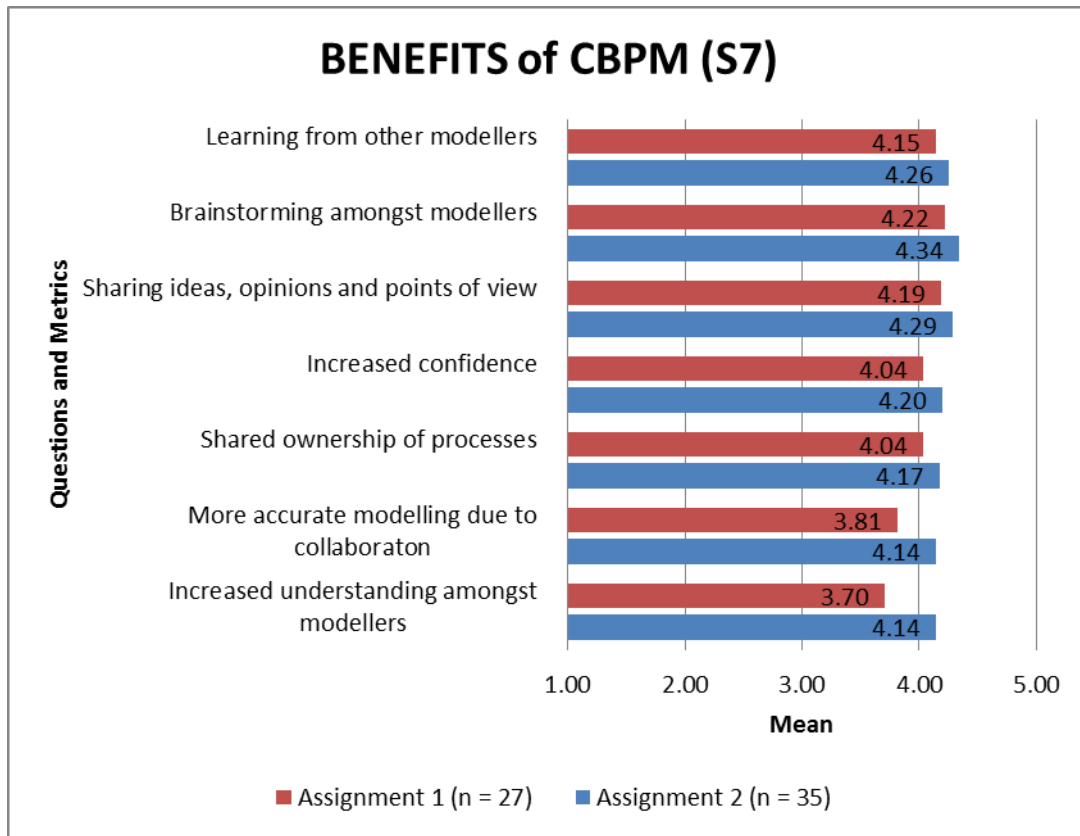
Figure 5.12: Benefits of CBPM

A qualitative analysis was carried out whereby participants' responses were colour-coded into categories and themes (Creswell 2009). The data analysis procedure (Figure 5.3) proposed by Creswell (2009) was applied in the following manner:

Step one: The data was obtained from web-based post-test questionnaires.

Step two: The data was thoroughly reviewed to gain a clear understanding of the information and to become familiar with the information.

Step three: The data was coded by hand, into different categories. The codes were based on similar responses from respondents.

Step four: Themes were derived from the codes to describe the results.

Step five: The themes are discussed in an appropriate manner.

In assignments one and two, eleven participants indicated that they found EA easy to use. This was the most frequently cited theme. The themes identified in assignment one and not in assignment two are: *EA is efficient* (f = 2), *EA is effective* (f = 2) and *EA has a clear interface*

(f = 2). The themes identified with regard to positive aspects of EA, in both assignments are shown in Table 5.6.

Table 5.6: Themes of positive aspects of EA

Positive Aspects	Assignment one frequency (f)	Assignment two frequency (f)	Total
EA is easy to use	11	11	22
EA is a good program that has what the functionalities the users require and it is intuitive	7	11	18
EA is easy to understand	3	4	7
EA is a powerful tool	0	2	2

Participants were also asked to list any challenges that they encountered with the modelling tool. Themes were identified with regard to the challenges of EA (Table 5.7). The two most frequent themes that were identified are: *participants battled with the layout of models and the alignment of the elements*, and *participants had a difficult time integrating the two models using EA*.

Table 5.7: Themes of challenges of EA

Challenges of EA	Assignment one frequency (f)	Assignment two frequency (f)	Total
Participants battled with the layout of the models and the alignment of the elements	8	6	14
Participants had a difficult time integrating the two models using EA	5	9	14
The overall use of the tool, understanding EA and finding the correct objects is a challenge	4	3	7
EA is not user friendly	3	2	5
Collaborating while using EA is a challenge	2	1	3

The participants were also asked to list any problems that they encountered while trying to combine the models. The problems encountered are addressed in Table 5.8. The most frequent theme identified was that *participants struggled to align objects in EA*.

Table 5.8: Problems encountered while combining models

Problems	Assignment one frequency (f)	Assignment two frequency (f)	Total
Participants struggled to align the objects in EA	7	10	17
Merging the two models were not easy	7	7	14
Participants had difficulties importing and exporting the two models	4	4	8

The participants were required to combine two models into one. They were then asked to indicate how EA helped them or did not help them to combine these two models. In assignment two, *the copy and paste function was deemed helpful* (f = 1) and *the user interface made the alignment of the models easier* (f = 4). Themes were identified in both assignments (Table 5.9). *EA did not help with combining the two models* is the most frequent theme that was identified.

Table 5.9: How EA helped/ did not help with integrating a model

How EA helped or did not help	Assignment one frequency (f)	Assignment two frequency (f)	Total
EA did not help with combining the two models	8	9	17
The import and export function in EA was helpful in combining the models	4	6	10

The participants gave *positive* ratings to the BPM Usability (S2), Collaboration (S3) and Benefits of CBPM (S7) sections. The Usability (S4) scored a *neutral* rating in assignment

one and a *positive* rating in assignment two. The Approaches to CBPM (S5) scored a *negative* rating in both assignments and a new BPM tool is therefore needed. Challenges of CBPM (S6) scored a *neutral* rating in assignment one and a *negative* rating in assignment two. Participants were however able to create a BP model using EA. A new BPM software tool (BPMTouch) will be designed and developed to overcome the usability issues of EA and support CBPM.

5.3. BPMTouch Design Considerations

BPMTouch is a software tool that will be designed and developed for CBPM. BPMTouch will also be evaluated in order to identify how usable the system is. The accuracy (Section 5.2.3) of BPMTouch will be tested in the BPMTouch evaluation. Several usability considerations also had to be taken into consideration. From the field study results it was clear that participants enjoyed EA because it was *easy to use*, *has an intuitive interface* and it *is a powerful tool* (Table 5.6). They however had challenges as *EA was not user friendly*, *the alignment of objects was challenging* and the *integration of models was challenging* (Table 5.7). The usability and design considerations that were taken into consideration for BPMTouch are:

- BPMTouch must be easy to use;
- The interface must be intuitive;
- BPMTouch must be user friendly;
- The alignment of objects should not be challenging; and
- Integration should be easy.

The first two considerations formed part of the non-functional requirements of BPMTouch (Table 4.2). *BPMTouch must be easy to use* and *the interface must be intuitive* and therefore *easy to learn*. ProcessCraft already allowed for modelling and no improvements had to be made for modelling in BPMTouch. The two considerations: *the software should be user friendly* and *the alignment of objects should not be challenging*, should have been taken into consideration with the design of ProcessCraft and are outside the scope of BPMTouch. The reason for this is that BPMTouch will not modify the functionality of ProcessCraft but merely adds a collaborative aspect to it.

The final consideration is that *integration should be easy*. BPMTouch took this even further and eliminated the need for integration as modellers are working on the same model.

5.4. Development of BPMTouch

ProcessCraft is a BPM application that was designed to help analysts and experts to describe solutions to identified business problems (Tabtou Ltd. 2012). The features of the standard ProcessCraft were investigated and evaluated by the researcher based on the knowledge gained from theoretical studies (Section 5.4.1) as well as the results of the field studies. The results of these investigations resulted in a list of software modifications that need to be made to ProcessCraft in order to develop BPMTouch (Section 5.4.2).

5.4.1. Touch-Based CBPM (ProcessCraft)

ProcessCraft is the first BPM tool that was designed with multi-touch input and it runs on all contemporary operating systems. ProcessCraft has several features that make the product a preferred BPM tool and these include:

- Extra fast graphic processing unit;
- Intelligent menus;
- Automatic resizing of pools;
- Automatic creation of executable xml;
- Automatic syntax error checking;
- Allows for collaboration;
- Provides an infinite drawing canvas; and
- Provides context specific help.

ProcessCraft was originally developed by a company called Tabtou and was developed in the Python programming language and runs on the Android platform, which is ideal for running on the Samsung Galaxy Tablet PCs. The software caters for the creation of BPMN models using a tablet and collaboration is supported by enabling users to save the model and email it to a client or stakeholder.

ProcessCraft allows for collaboration by providing users with the opportunity to enter a presentation mode in which the menus and background grid are removed in order to display

the model in full screen. An image can then be generated and loaded into the user's email for distribution to the relevant clients or stakeholders.

The navigation of ProcessCraft (Figure 5.13) includes the diagram canvas, symbol pallet, symbol menu, properties pane, help, presentation mode, intelli-menu, gestures and presentation mode (Tabtou Ltd. 2012). The diagram canvas is a drawing board that carries on indefinitely, depending on the memory of your device. Users do not have to limit their model size to the screen size. The symbol pallet allows users to carry out a drag and hold gesture to pull the symbol from the symbol pallet onto the diagram canvas. The symbol menu is triggered by double touching or tapping a symbol that has been put onto the canvas from the symbol pallet.

The properties pane is triggered by touching the black rectangle in the right hand bottom corner once. The properties pane is comprised of the required parameter values to complete the BPMN model. The parameter list provides information that is context sensitive to the selected symbol on the canvas.
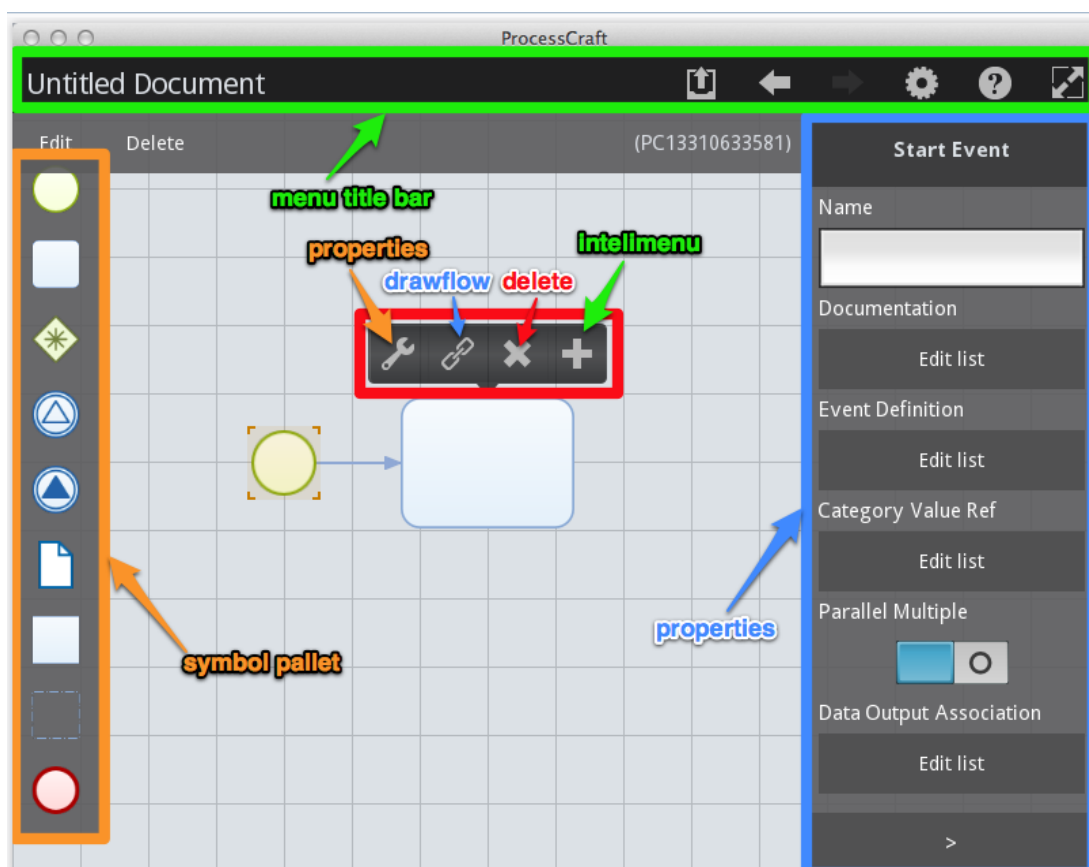
Figure 5.13: ProcessCraft navigation screen (Tabtou Ltd. 2012)

117

The help icon is situated in the menu title bar and it provides users with access to the ProcessCraft website (Figure 5.14). Context sensitive help is also provided in the menu bar of the properties pane. The icon in the top right hand corner of the navigation window, which is two arrows pointing in opposite directions, is used to enter presentation mode. The presentation mode provides users with a full-screen canvas on which the diagram can be navigated by the use of a drag gesture. The intelli-menu can be triggered by selecting the "+" sign which appears on the symbol pop-up menu (Figure 5.13).

Instead of using the Symbol Pallet to add symbols to the diagram canvas, users can use the intelli-menu (Figure 5.15). Once the intelli-menu is open, users can touch the element which they would like to add to the model and it will be added after the current element in the model. The first icon in the intelli-menu is to add an annexure to the model. The rest of the icons in the top row and the second row consists of all the intermediate events that can be used between the start and end events. The third row are all end events (red circles), the fourth row lists all different types of gateways and the bottom row contains different types of tasks.
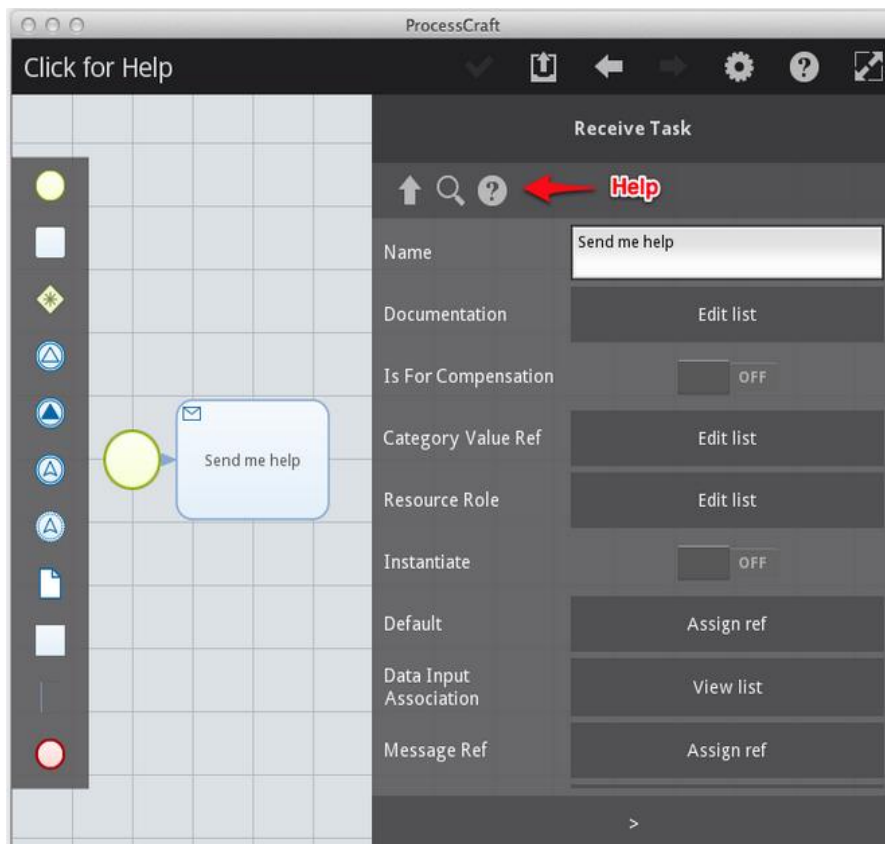
Figure 5.14: Help menu (Tabtou Ltd. 2012)
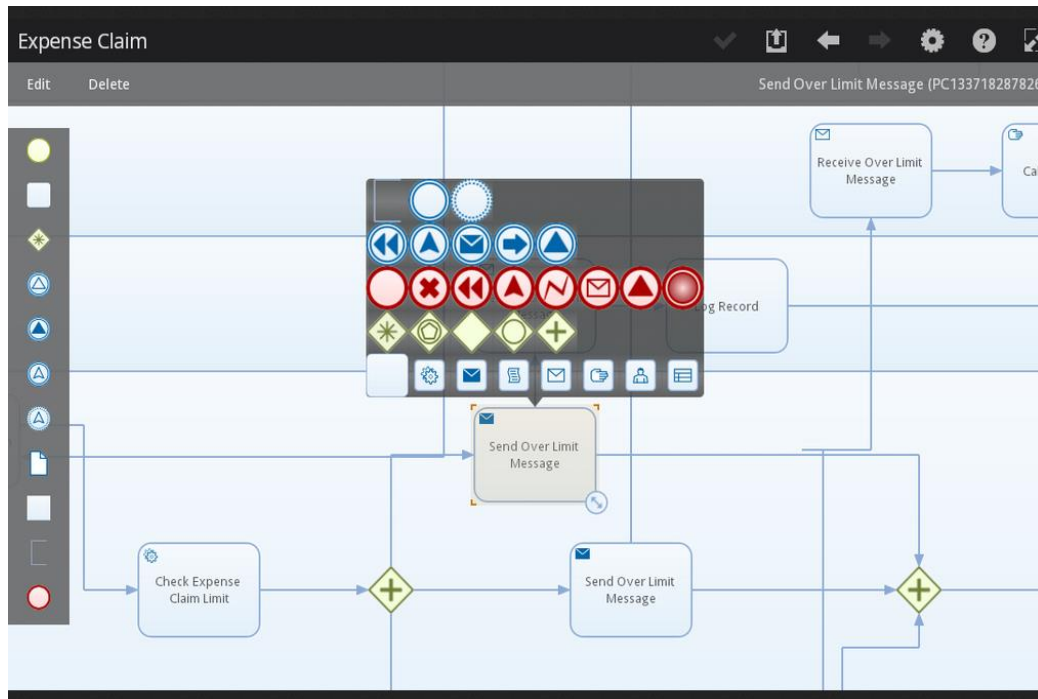
Figure 5.15: Intelli-menu (Tabtou Ltd. 2012)

Pinch (pinch two fingers together) and scale (drag two fingers apart) gestures are recognised by ProcessCraft and can be used to scale the canvas (Figure 5.16). This allows users to add more or less symbols into the viewing area of the canvas. A single finger drag can be used against the background of the drawing canvas and will result in the panning of the diagram in any desired direction on the infinite viewing canvas.
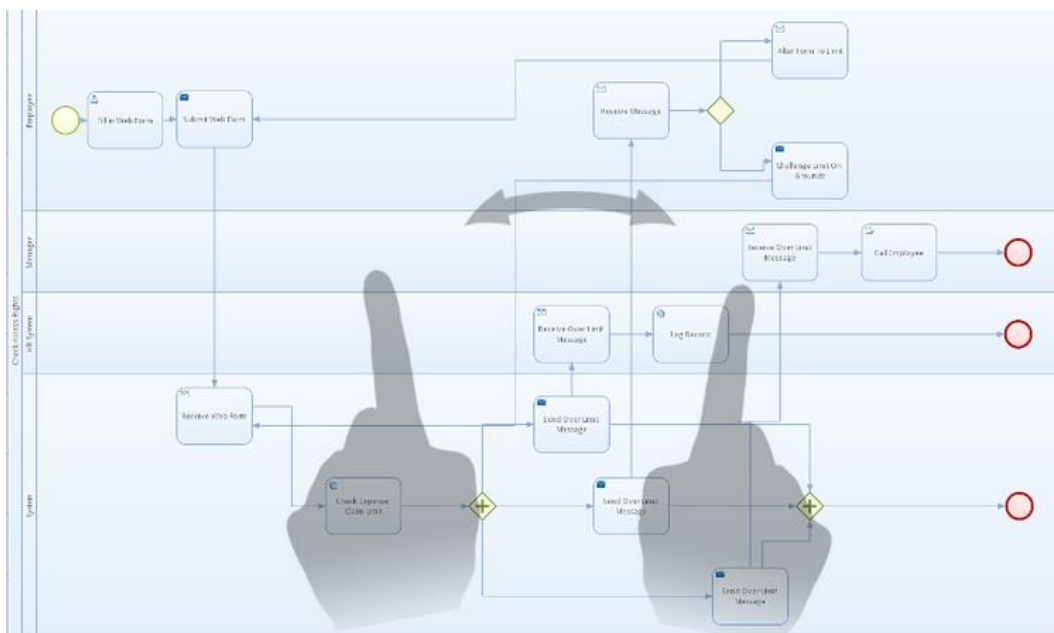
Figure 5.16: Gestures (Tabtou Ltd. 2012)

119

The save and share icon can be found on the menu title bar and accessed with a single touch (Figure 5.17). Diagrams can be saved as a BPMN document, or shared as a BPMN 2.0 XML or PNG Graphic file.
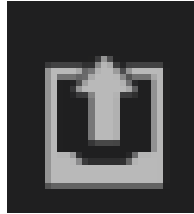
Figure 5.17: Save and share icon (Tabtou Ltd. 2012)

ProcessCraft provides users with the opportunity to draw three levels of BP diagrams (Tabtou Ltd. 2012). Analysts and experts usually look at the big picture of the business problem before going into more details and iterating into lower levels. Generally the modelling cycle progresses from level one to level two and finally iterates to level three. This can however change, based on the process being modelled and the modeller's preferences.

The level one diagram may describe the business problem or it could be the first step to reaching the end objective. Sometimes domain experts are not familiar with BPMN 2.0 and therefore use a subset of the Symbol Pallet in level one to simplify the amount of knowledge that needs to be consumed for all the project members. Level one is also not focussed on syntax rules and therefore can often fail the validation rules. In level two, users should not be constrained from using the entire 116 Symbol Pallet; however, the models should conform to the BPMN 2.0 standard. The purpose of level three modelling is to get the model to a state where it is executable. This sometimes leads to limiting the use of several symbols and the execution flow needs to be compliant with the specified vendor runtime tool. Analysts therefore need a considerable amount of knowledge about the vendor runtime engine before modelling at this level.

5.4.2. BPMTouch Software Modifications

The BPMTouch software tool is a combination of existing software (ProcessCraft) and alterations and upgrades made to the software. Tabtou, the company that created ProcessCraft, was contacted and asked for the source code to their software and permission to make changes to code. The software was evaluated by the researcher in order to determine if it could satisfy the objectives and functional requirements identified in Section 4.3.

It was determined that ProcessCraft satisfies two of the high level objectives and one of the functional requirements (Table 5.10).

Table 5.10: Satisfaction of high level objectives and functional requirements

Number	Type	High Level Objectives and Functional Requirements	Requirement Satisfied by ProcessCraft
1	Objective	The software must allow the users to draw BP models	Yes
2		The software should cater for collaboration amongst a small team of modellers (a minimum of two modellers)	No
3		The software must support the SIDV collaboration style	
4		The software must run on a tablet PC	Yes
1	Requirement	The software must support the BPMN	Yes
2		The software must allow users to collaborate by updating the models on all of the connected devices	No
3		The software must allow for coordination	
4		The software should have built-in client and server capabilities	
5		Up-to-date information needs to be displayed on all tablets	
6		The software must have a built-in locking mechanism	
7		The software should allow multiple users to use it in the same place and same time (co-located and synchronous)	

Modifications had to be made to the source code of ProcessCraft in order for the software to meet all of the requirements for this study. A proper network connection had to be

established between multiple tablet PCs, a collaboration aspect had to be built-in in order to follow the SIDV collaboration style (Section 4.2.1) and a locking mechanism had to be implemented in order to satisfy the synchronisation functionality.

ProcessCraft is based on the Kivy framework, which was written in Python. Any application built using this framework can be deployed on a variety of platforms (including Microsoft Windows, Linux, Android, iOS and OSX) without any additional programming required. It does, however, require an advanced understanding of Python. Knowledge of networking protocols and transmission was also a requirement in the development of BPMTouch to facilitate the client/server architecture.

The researcher designed the additions that needed to be added and developed parts of the code as well as the user interface for the collaboration screen (Figure 5.19). In order to run the software properly, different technologies were required to interact. Components of the final technical code implementation were therefore outsourced. Tabtou enforced that non-disclosure agreements be signed by the author and the technical programmer, therefore, none of the code extracts can be shown or discussed in detail in the dissertation.

Upon completion of the software prototype (BPMTouch), the source code was given to Tabtou so that they can use it to improve ProcessCraft. The original ProcessCraft's landing screen was similar to the one below; however, the BPMTouch design has a collaboration button built into it (Figure 5.18).

Figure 5.18: BPMTouch landing screen

A collaboration function was added to cater for a minimum of two users (one per tablet PC). This function is activated when a user clicks on the collaboration button, in which one tablet PC acts as a server and clients can connect to the server wirelessly by entering the server's IP address into the dedicated field (Figure 5.19).
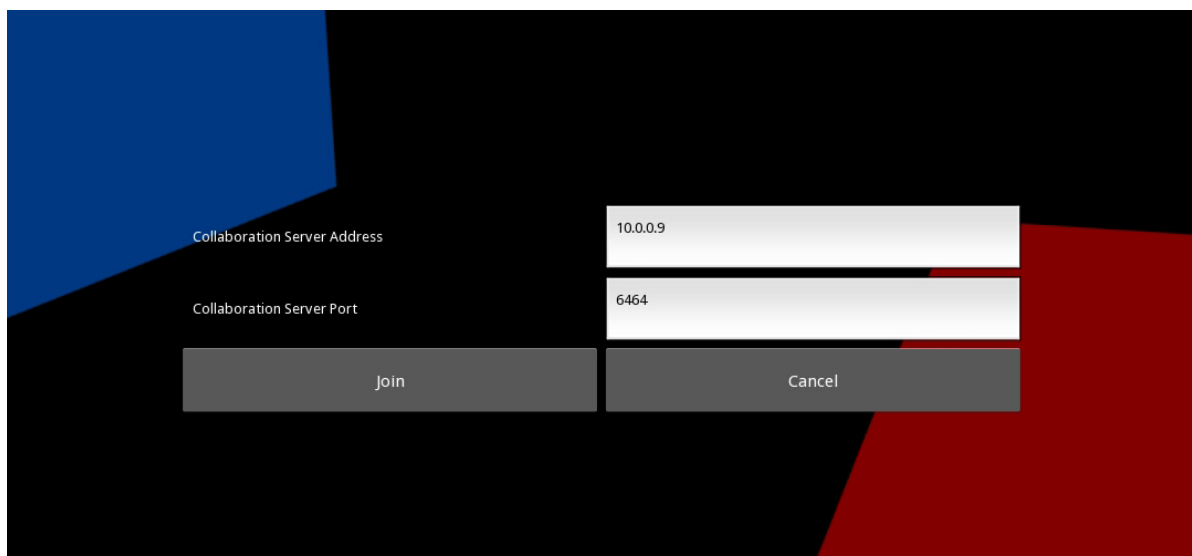
Figure 5.19: Client connecting to a server

123

Upon connection to the server, clients automatically "share" a screen with the server tablet, whilst using their own tablet. In order to cater for proper coordination (Section 3.2) between modellers, a locking mechanism (flag) had to be implemented. A flag was therefore added to the software which indicates who has control over the software. If the flag is available, any user (server or client) can take the flag (which triggers a locking mechanism) and manipulate the model. All the changes made to the model can be seen by any other party that is connected to the server. The locking mechanism disables other users' ability to manipulate the model while someone else is modifying the model. However, all changes made can be seen by all the users on their own tablet PC (Figure 5.20). In this way collaboration is promoted as users do not have to save the model and book it into a repository or email it to a co-worker. The changes can be seen by everyone as they are made and stakeholders can agree or disagree immediately.

One user will always be the "server" and all other participants can connect to the server as clients. A locking mechanism has been added to the source code to ensure that only one participant (with the green flag) can modify the model at any given point in time. Once the modeller has modelled enough, the flag can be passed to a different modeller. The current modeller only taps on the green flag and the flag will then go white. All of the connected devices will show a white flag. The first participant to tap on the white flag will then have the right to write and a green flag will appear on that device. The rest of the participants will have a red flag indicating that they have read-only rights. A client-server architecture has been built in and it relies on Wi-Fi to work correctly. This functionality allows for collaboration and the updating of models on each device (Figure 5.20).

Most of the non-functional requirements were built into ProcessCraft, therefore, no additional changes had to be made to the source code for non-functional requirements. Therefore, BPMTouch caters for coordination by the use of flags, collaboration by updating the models on each device and communication by means of working in a co-located environment where modellers can talk to each other (Section 3.2). The high-level objectives and functional requirements (Section 4.3) have been met.
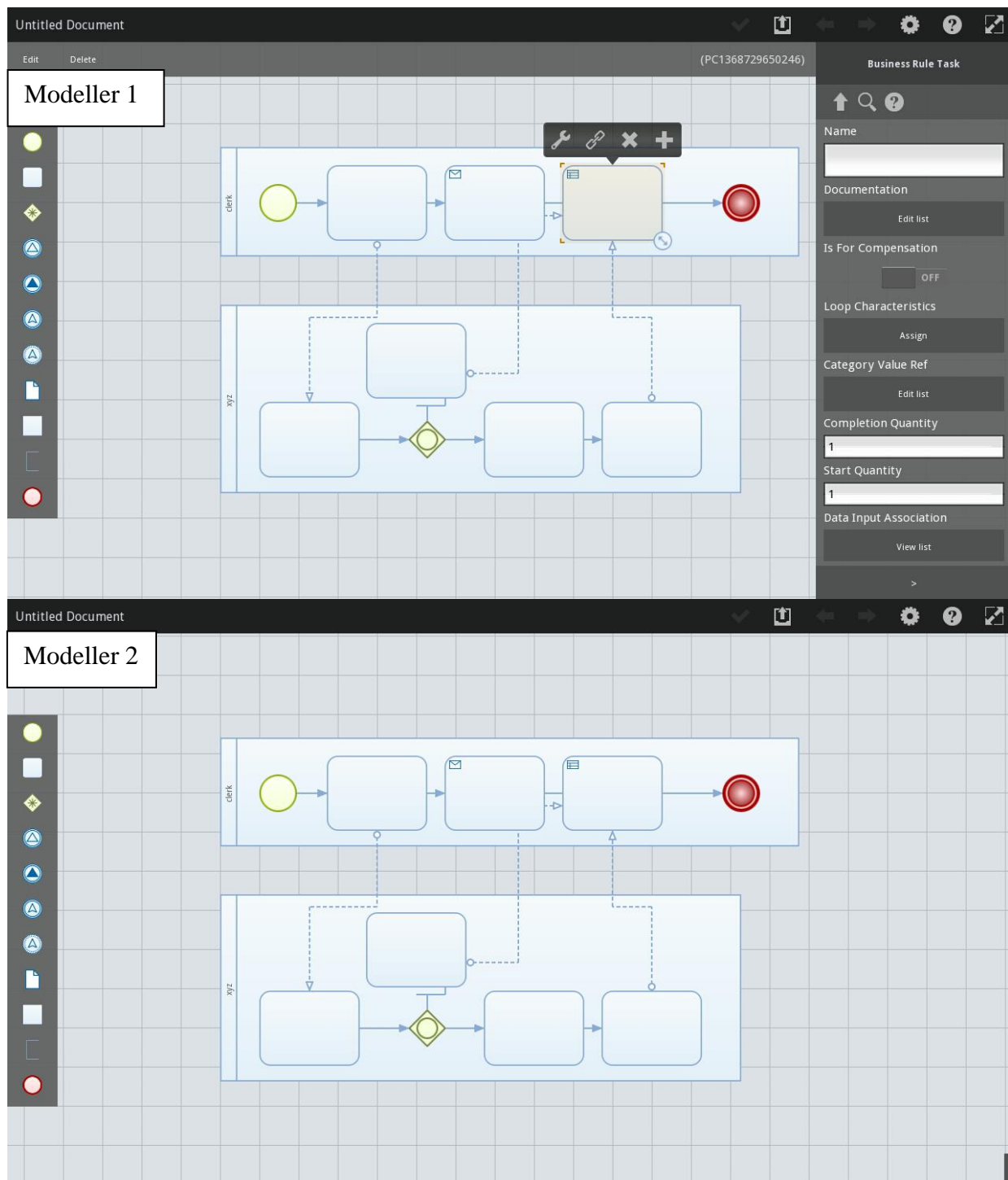
Figure 5.20: Example of two users working on the same model

5.5.   Conclusion

This chapter discussed the design and development of BPMTouch, the software artifact which completed Activity 3 of DSR (Section 1.10.2). The DSR methodology requires measures for evaluating the artifact. Usability metrics such as efficiency, effectiveness and satisfaction were used in a preliminary evaluation of EA, a popular BPM tool (Section 5.2.4.4). The field study with both assignments was discussed and the overall result is that many of the participants struggled with integrating the models using EA. The original software, ProcessCraft was discussed and the workings and navigation of the software were explained (Section 5.4.1).

The results of the field study and the capabilities of ProcessCraft were taken into consideration for the design and development of BPMTouch (Section 5.4.2). As integration seemed to be the aspect of EA that most of the participants struggled with, it was only logical that BPMTouch was designed to update in real-time so that the integration aspect could be eliminated entirely. The problems that were identified by using EA were used for the design of BPMTouch. The objectives, functional and non-functional requirements were also taken into consideration for BPMTouch. BPMTouch incorporates the functionality to allow modellers to coordinate, collaborate and communicate which forms part of CSCW (Chapter 3). This chapter answered *RQ$_5$: "What are the usability criteria and design considerations of current BPM tools?"* and the considerations are:

- BPMTouch must be easy to use;
- The interface must be intuitive;
- It must be user friendly;
- The alignment of objects should not be challenging; and
- Integration should be easy.

Chapter 6 will investigate the evaluation of the BPMTouch software and report on an analysis of the results of this evaluation.

Chapter 6

BPMTouch Evaluation

6.1. Introduction

This chapter addresses two activities in the DSR methodology, namely demonstrate the artifact and evaluate the artifact. The tablet PC was chosen as the hardware platform for BPMTouch. Chapter 5 introduced the usability metrics identified for evaluating a CBPM system and reported on a field study of an extant system where these usability metrics were used. The results of the field study were incorporated into the design and modification of the ProcessCraft software tool (Chapter 5).

This chapter focusses on the evaluation of the BPMTouch software tool in order to determine the usability and success of the software which forms part of the final artifact of this study (Section 6.2). The main usability metrics are efficiency, effectiveness and satisfaction, as documented in the thesis statement (Section 1.4). This chapter will therefore answer RQ_6: *"How can software for CBPM be evaluated?"* The objectives and requirements of a CBPM software solution (Section 4.3) are revisited in order to determine whether the requirements were met and the objectives fulfilled (Section 6.3). Figure 6.1 shows the chapter layout and deliverables.

Chapter 1	Chapter 2	Chapter 3	Chapter 4	Chapter 5	**Chapter 6**	Chapter 7
Introduction	Business Process Modelling	Problem Identification of Collaborative Business Process Modelling	Objectives of a Collaborative Business Process Modelling Touch Solution (BPMTouch)	Design and Development of the BPMTouch Software Tool	**BPMTouch Evaluation**	Conclusion and Recommendations for Future Research

6.1. Introduction

6.2. BPMTouch Evaluation

6.3. Fulfilment and Analysis of Requirements

6.4. Framework for CBPM (Version 2)

6.5. Conclusion

Research Objectives

Deliverables

RO₆: Evaluate the software prototype (BPMTouch) for CBPM.

Framework for Co-located CBPM Using Touch Technologies

BPMTouch software tool

Figure 6.1: Chapter 6 layout and deliverables

6.2. BPMTouch Evaluation

A heuristic evaluation is carried out by evaluators who look at a user interface and form an opinion about it (Nielsen and Molich 1990). They recommend that three to five participants are used for a heuristic evaluation as the evaluation reaches a point of diminishing returns after five subjects. Virzi (1992) carried out three experiments and also concluded that five

subjects are sufficient for a usability study. A large set of participants is not required in thinking-aloud studies and approximately five subjects are enough for a thinking-aloud study (Nielsen 1994). Therefore, five subjects are sufficient for a usability evaluation (Nielsen and Molich 1990; Virzi 1992; Nielsen 2000, 2012).

6.2.1. Research Instruments and Metrics

Section 5.2.1 discussed the research instruments used for the field study and the evaluation of BPMTouch. Table 5.1 documented the identifier, material description, data analysis and type of classification relating to the research instruments used. The post-test questionnaire used in the BPMTouch evaluation (PT_2: Appendix Q) is made up of ten sections. Section 1 consists of biographical details such as age, gender, years of experience with computers, touch devices and BPM concepts. Participants were also asked whether they had experience with BPM or UML modelling. Section 2 required participants to answer questions relating to task completion and to record the task time. Section 3 focussed on collaboration in order to find out whether the participants carried out the tasks in a collaborative manner, coordinated and communicated with their partners. Section 4 was the usability section of the questionnaire and this is the standard PSSUQ questionnaire. Section 5 asked participants to indicate whether they struggled to integrate the models or to manage their time.

Gesture manipulation, Section 6, focusses on the gesture input that the participants had to provide to interact with the tablet PCs. In Sections 7 and 8 the participants were required to list the positive features and the negative features of BPMTouch. Section 9 required participants to select whether they prefer traditional PC systems or BPMTouch and to provide a reason for their selection. Lastly, Section 10 provided for any additional comments that the participants might have had. Sections 1 to 6 are statements with a 5-point Likert scale rating. Participants had to rate the statements from 1 (strongly disagree) to 5 (strongly agree). Sections 7 to 10 comprised open-ended questions.

Face validity of the questionnaire was established by using questions based on literature and the results from the initial pilot study and the field study. Content validity was established by means of a pilot study. A pilot study was carried out with a pair of participants to test the software, questionnaire reliability and to ensure that there is no ambiguity in the task list (T_2: Appendix R) or the questionnaire (PT_2: Appendix Q) as well as the overall evaluation. The task required participants to work in teams of two and to record their start and end times for

drawing a process model using BPMTouch. The examiner did not dictate how the process model had to be drawn or how the team members shared modelling activities. The pilot participants completed the task in 41 minutes. No changes were made to the questionnaire after the pilot study. The following metrics formed part of the evaluation (Section 5.2.3):

- **Effectiveness** was measured by the post-test questionnaires in which the participants had to say whether BPMTouch is effective and by calculating the number of successful tasks compared to the unsuccessful tasks;

- **Efficiency** (task time) was measured by recording the time it took each pair of participants to complete the time. The times were compared to the pilot studies which were carried out by experts who are familiar with touch, collaboration and BPM;

- **Satisfaction** was determined by the results of the post-test questionnaire;

- **Collaboration** was measured by the post-test questionnaire;

- **Accuracy** was determined by the quantitative results of the post-test questionnaires (based on the number of participants that preferred BPMTouch over EA); and

- **The gesture manipulation** was measured by the post-test questionnaire and added specifically for this evaluation.

6.2.2. Participant Profile

The BPMTouch evaluation was carried out by four pairs of students and five pairs of industry participants in a thinking-aloud environment as the partners were allowed to communicate with each other and discuss BPMTouch as well as the tasks. The students were selected based on their marks obtained in the second year BPM course offered at NMMU. The selected students all obtained a minimum of 60% for the BPM course and participation was voluntary. Eight student participants took part in the evaluation and they were all between the ages of 18 and 25. Five participants were males and three were females. Fifty percent (n = 4) had more than ten years' experience with computers, 37.5% (n = 3) had between six and ten years' experience and 12% (n = 1) had one to five years' experience with computers. All of the participants (100%) had experience with BPM and were able to complete the task successfully.

Ten industry participants completed the evaluation of which eight were males and two were females. The majority of the industry participants (n = 7) were between the ages of 26 and

35. Ninety percent of the industry participants had had more than ten years' experience with computers and 90% had had one to five years' experience with touch computers. Only one participant (10%) had had six to ten years' experience with touch devices. Eighty percent (n = 8) of the industry participants had BPM experience and 70% (n = 7) had experience in other modelling such as UML. The industry participants were selected based on the criteria that they had some modelling experience in either BPM or UML modelling. Therefore, 100% (n = 10) of the participants had modelling experience. Eighty percent (n = 8) of the participants were able to complete their task successfully and 20% (n = 2) managed to partially complete their task.

The evaluations had to be carried out in a group environment in order to evaluate the collaboration of the BPMTouch software tool (Tse *et al.* 2007). Before each evaluation, the reason for the evaluation was explained to the participants; they were required to sign a consent form and a task list and they were given a short introduction to BPMTouch. All of the evaluations were video recorded with the participants' consent.

6.2.3. Results

The students evaluated BPMTouch first. All four pairs of students decided not to practise using the software and started with the evaluation straight away. The first evaluation was the quickest and was completed in 15 minutes and the second evaluation was completed in 17 minutes (Table 6.1). The third and fourth evaluations took longer due to technical issues. Evaluation three took 28 minutes as the client tablet was not updated before the flag was handed over from the server. The student working on the client tablet then started updating the model and all of the updates made by the server were lost. The students therefore had to re-do a part of the model and extra time was required to complete the model. The fourth evaluation was completed within 22 minutes. The student using the server tablet modelled part of the model and then handed over the flag to the client. Once the client participant tried to perform the tasks, it became evident that the tablet PC's keyboard did not work and the tablet had to be restarted to gain keyboard functionality. Participants therefore lost time due to restarting the tablet.

The five pairs of industry participants also decided not to practise using the software and started with the evaluation straight away. The fastest completion time was the second pair who completed the evaluation in 18 minutes, followed by the fourth pair who completed it in

19 minutes (Table 6.1). The first group completed the evaluation in 21 minutes and the fifth group in 25 minutes. The third group did not manage to finish the task due to errors being made and as BPMTouch crashed several times. The reason for this could be that the tablet PCs were not restarted before this session but they had been previously restarted and therefore refreshed before the start of all the other sessions. The participants also moved the elements around very quickly and the Wi-Fi speed and rate of updating on the client tablet PC was too slow.

Table 6.1: BPMTouch evaluation with total task time

Team Number	Total Task Time (minutes)
Student Evaluation	
1	15
2	17
3	28
4	22
Mean Time	**20.5**
Industry Evaluation	
1	21
2	18
3	Did not finish
4	19
5	25
Mean Time	**20.75**

All of these evaluations indicate that students and industry members can be efficient using BPMTouch as the evaluations were all carried out in less time than the pilot study time of 41 minutes. The mean times for the students and participants from industry are very similar, based on all completed tasks. BPMTouch is therefore an efficient BPM software solution as participants could complete their tasks quickly and accurately (Nielsen 1993; Seffah *et al.* 2006; Rubin and Chisnell 2008). All the participants could also be effective while using BPMTouch as 89% of the pairs (eight out of nine pairs) were able to successfully and

accurately complete the task (Donyaee 2001; Seffah *et al.* 2006). Satisfaction, gesture manipulation and collaboration are discussed, based on the post-test questionnaire results.

For the collaboration section, the majority (88%) of students agreed that both of the team members participated with a mean rating ($\mu = 4.50$) higher than four (Figure 6.2) and 100% of industry participants agreed that both team members participated ($\mu = 4.70$). "*My experience with CBPM in this exercise has been positive*"; was one of the top rated comments from students ($\mu = 4.50$) and industry ($\mu = 4.40$) and received a mean rating larger than four. "*I can easily share ideas using this system*" is the only statement which received a mean value less than four from both students and industry. Generally, for both students and industry participants, the ratings were in the *positive* range for all of the collaboration statements. These results confirm that BPMTouch is an effective software solution for CBPM.
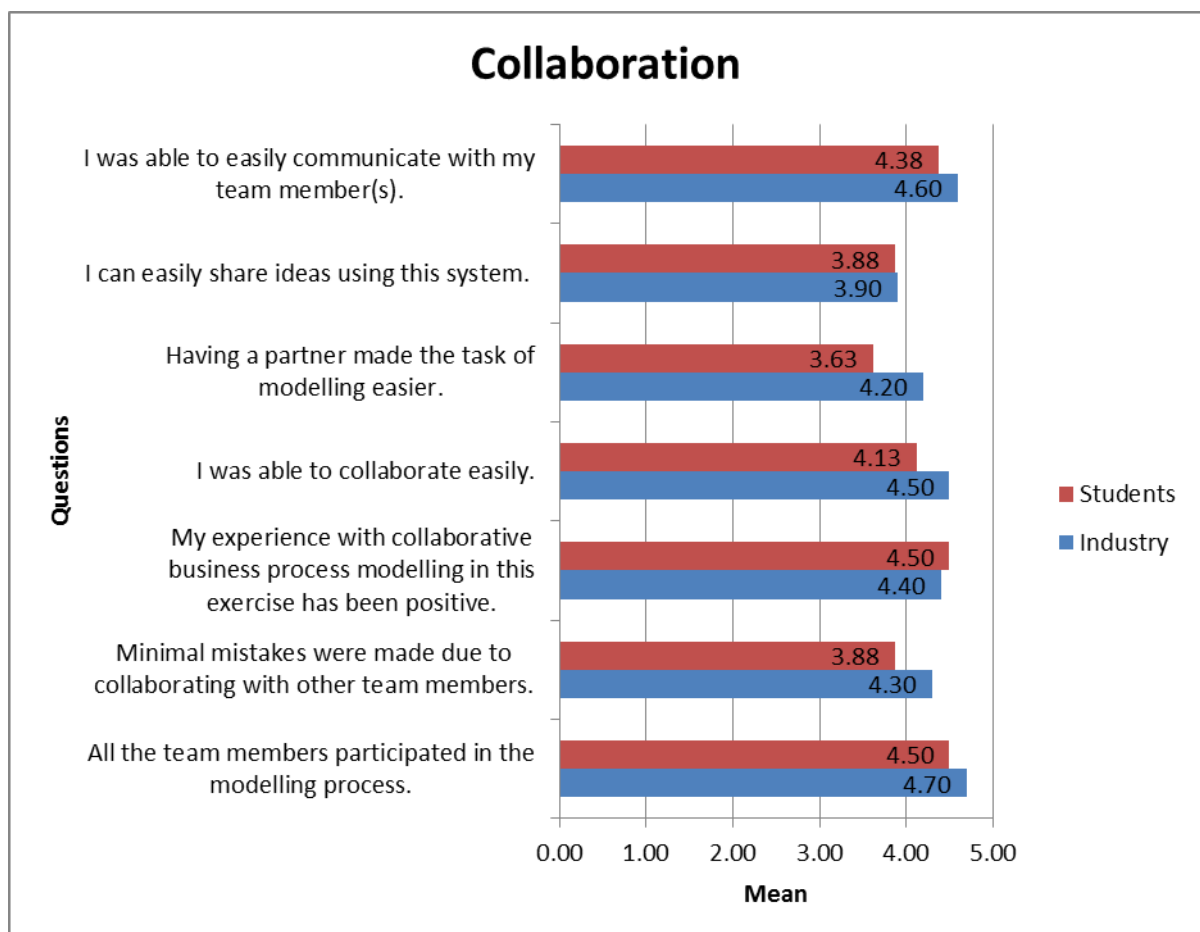
Figure 6.2: Collaboration

The SIDV collaboration style (Isenberg *et al.* 2010) documented in Chapter 4 was followed by all of the participants. Figure 6.3 shows how the two participants in a pair each looked at

their own model while the modeller in charge was modelling. In most cases the participants divided the diagram between them so that both participants had a chance to model on BPMTouch and to experience the software. Figure 6.4 shows a completed model. When a participant was stuck, the partner would help by either explaining what to do or by showing his/her partner on their tablet PC. In several cases, one participant read the object labels out loud and the partner would then type in the labels.

Figure 6.3: A pair of industry participants evaluating BPMTouch
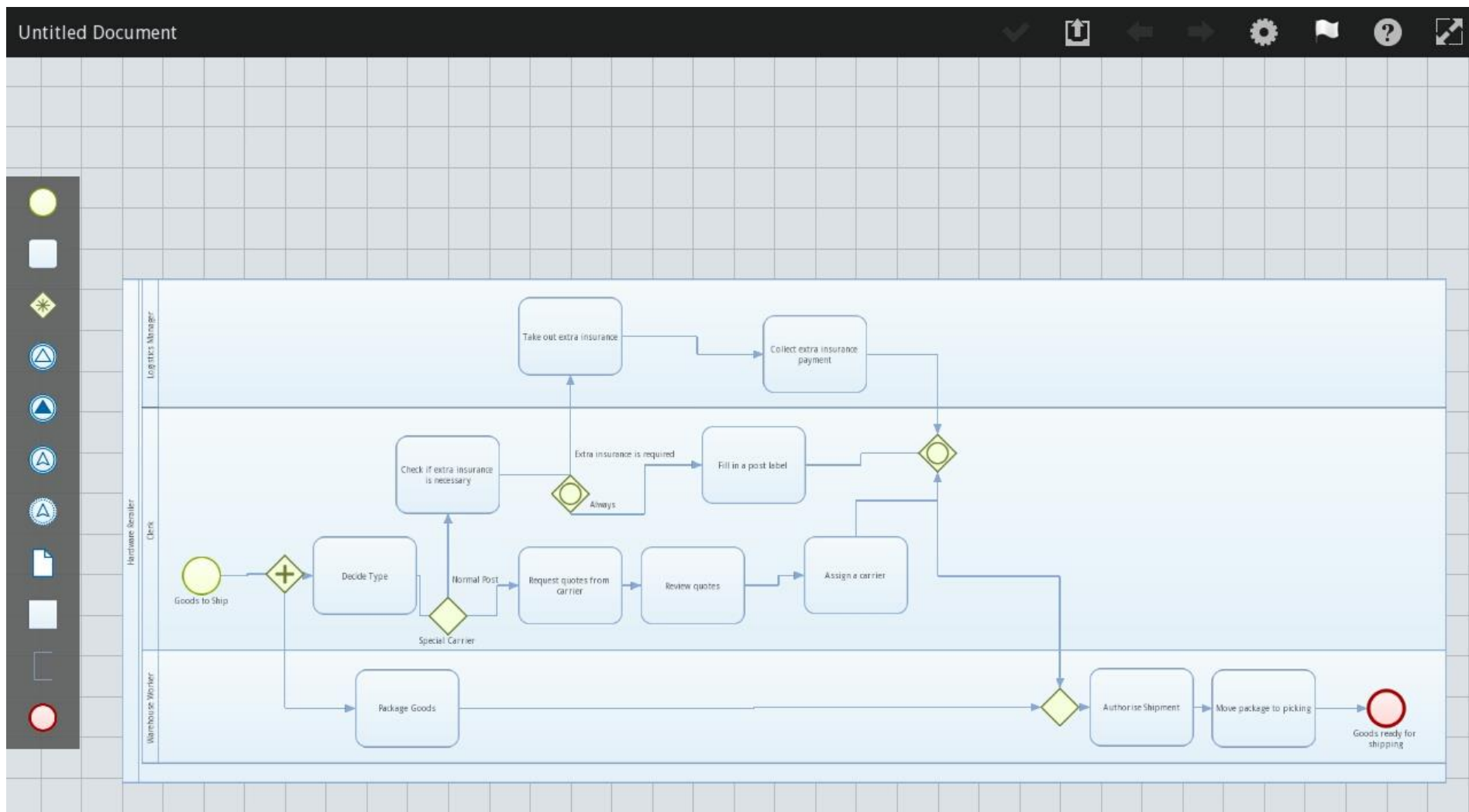
Figure 6.4: A completed model by a pair of industry participants

The largest mean score (μ = 4.63) in the usability section of the post-test questionnaire completed by the students was for "*BPMTouch was easy to learn*" (Figure 6.5). The highest rated statements by industry participants is that "*The Interface is pleasant*" and they "*Liked working with the interface*" (μ = 4.40). In general, participants were satisfied with the usability of BPMTouch with the majority of the questions receiving a mean score higher than four which is in the *positive* range. The lowest rated statement was for "*The system gave error messages that clearly told me how to fix problems*" ($2.6 \leq \mu \leq 2.63$). The mean scores show that students and industry participants were neutral towards the fact BPMTouch provided clear error messages with a mean score. The statement, "*I am satisfied with BPMTouch*" received mean ratings in the *positive* range ($4.00 \leq \mu \leq 4.38$) for both student and industry modellers, indicating that BPMTouch is satisfying (Nielsen 1993; Seffah *et al.* 2006; Rubin and Chisnell 2008; Sauro 2011).

The OVERALL, SYSUSE, INFOQUAL and INTERQUAL scores for the student evaluations of BPMTouch (Table 6.2) are higher than the results for the field studies. The scores were mostly above four out of five ($3.54 \leq \mu \leq 4.38$) which is in the *positive* range. The students gave a better usability rating in all four cases, OVERALL, SYSUSE, INFOQUAL and INTERQUAL, compared to the industry ratings. Generally, both industry and student participants gave high ratings for the usability of BPMTouch and their responses do not differ greatly.

Table 6.2: Rules for calculating PSSUQ scores and evaluation results (Lewis 1995; Lewis 2002)

Score Name	Student Evaluation (μ)	Industry Evaluation (μ)
OVERALL	4.12	3.92
SYSUSE	4.28	4.11
INFOQUAL	3.79	3.54
INTERQUAL	4.38	4.27

Usability

Question	Students	Industry
I am satisfied with BPMTouch	4.38	4.00
BPMTouch has all the capabilities needed	4.38	4.00
I liked using the interface	4.50	4.40
Interface was pleasant	4.25	4.40
Clear organisation of information	4.00	4.00
Information effective to help me	4.25	4.10
Easy to understand information	4.13	3.80
Easy to find information	4.13	3.60
Clear information provided	4.00	3.70
Recover easily from mistakes	3.38	3.00
Clear error messages	2.63	2.60
Be productive with	4.38	4.30
BPMTouch was easy to learn	4.63	4.20
Comfortable using	4.38	4.00
Complete tasks efficiently	3.63	4.30
Could complete tasks quickly	4.00	3.90
Complete tasks effectively	4.50	4.10
Simple to use	4.50	4.20
Easy to use	4.25	3.90

Figure 6.5: Usability (PSSUQ)

The gesture manipulation (Figure 6.6) feature was *positive* according to the participants with all the mean scores higher or equal to four (4.00 $\leq \mu \leq$ 4.63). Therefore participants agreed that *"having touch computers made collaboration easier"*, *"it was easy to interact with BPMTouch using the gestures"*, *"gestures were logical and easily remembered"*, *"objects were large enough to allow for touch"* and *"BPMTouch correctly interpreted the gestures"*. The highest rated statement by students was "g*estures were logical and easily remembered*"

138

(μ = 4.63) and the highest rated statement by industry was "*having touch computers made collaboration easier*" (μ = 4.50). The lowest rated statement from students and industry was "*BPMTouch correctly interpreted the gestures*" (4.00 $\leq$ μ $\leq$ 4.13). Another low rated statement by industry was "*objects were large enough to allow for touch*" (μ = 4.00).
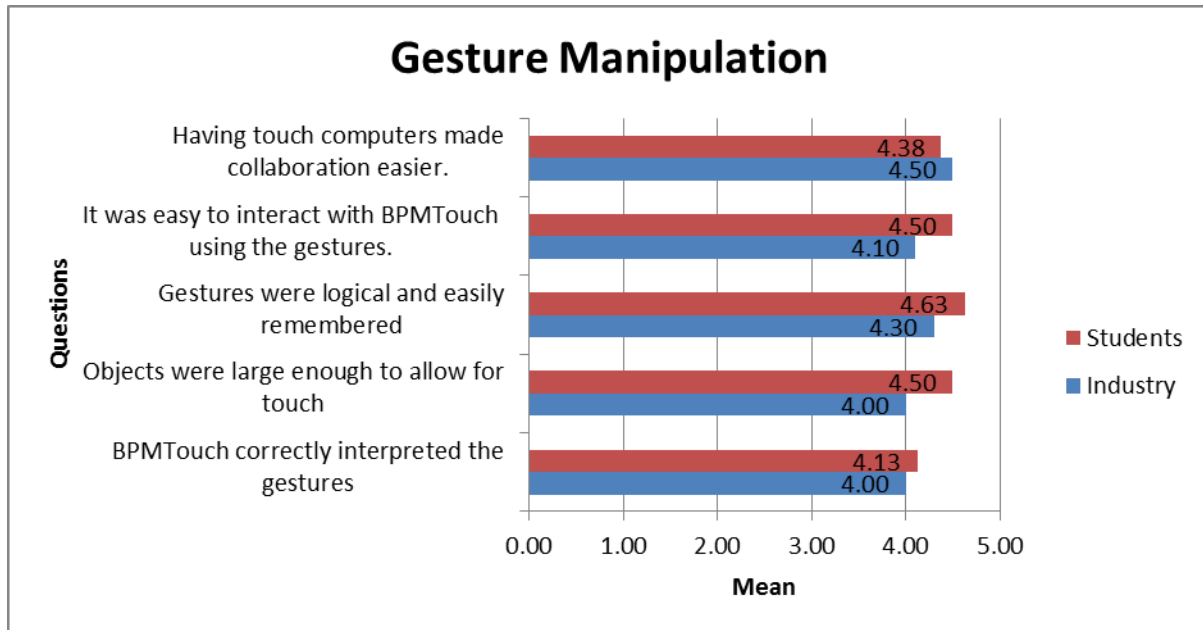
Figure 6.6: Gesture Manipulation

The participants were asked to list any positive aspects relating to the use of BPMTouch (Table 6.3). Two of the students indicated that BPMTouch is useful and productive. Industry participants mainly commented on the ease of use and collaboration. The majority (80%) of industry participants indicated that the collaborative functionality is a positive aspect of BPMTouch. The most frequent theme for positive aspects of BPMTouch is "*it works well for collaborative purposes*" (f=10).

Table 6.3: Main positive aspects identified by students and industry

Positive Aspects	Students Frequency (f)	Industry Frequency (f)	Total
It works well for collaborative purposes	2	8	10
BPMTouch is easy to use	3	6	9
The touch is easier to use than the normal desktop PC and mouse	2	1	3

The participants were also asked to rate the perceived challenges of BPM as they were encountered with the BPMTouch software tool. The challenges (Figure 6.7) of BPMTouch are limited as participants did not agree with the challenges identified in theory for traditional BPM tools used for CBPM. All of the mean scores are below three ($1.63 \leq \mu \leq 2.75$). This is a positive result for BPMTouch since all of the scores are *neutral* or *negative* indicating that the participants did not agree with the challenges. The highest rated challenge by students was "*Struggled to integrate our models*" ($\mu = 2.75$); and this is in the *neutral* range. The rest of the mean scores are all in the *negative* range. The highest rated challenge for the industry participants was "*We struggled to manage our time due to collaboration*" ($\mu = 2.00$). The lowest rated challenge by students was "*We struggled to manage our time due to BPMTouch*" ($\mu = 1.63$) and the lowest rated challenges by industry were "*We struggled to manage our time due to BPMTouch*" and "*Struggled to integrate our models*" ($\mu = 1.80$).
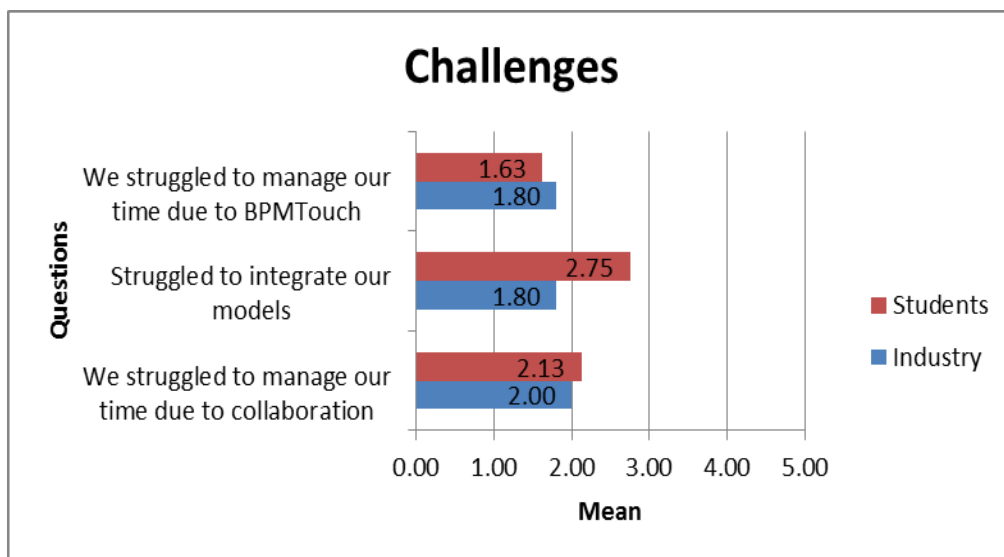
Figure 6.7: Challenges of BPMTouch

Participants were also required to list any additional challenges that they had with BPMTouch. The participants indicated that several challenges might have been due to the tablet PC and not BPMTouch. Tablet PC issues were that the keyboard was difficult to use and the device is slow. Two students indicated that the connection between the Tablet PCs was faulty at times and two industry participants said a challenge for them was that as BPMTouch did not have an undo function, they had to delete objects and redo the function. The additional challenges of BPMTouch were recorded (Table 6.4). The most frequent theme identified in the challenges of BPMTouch was "*the objects were difficult to move around*" (f

= 6). Other themes identified are "*The tablet PC gave problems which were not necessarily related to BPMTouch*" (f = 5), "*Integration or updates on the second tablet was slow at times*" (f = 4) and "*There were small bugs in the software which was challenging to work with*" (f = 4).

Table 6.4: Additional challenges of BPMTouch

Challenge	Students Frequency (f)	Industry Frequency (f)	Total
The objects were difficult to move around	2	4	6
The Tablet PC gave problems which were not necessary related to BPMTouch	2	3	5
Integration or updates on the second tablet was slow at times	1	3	4
There were small bugs in the software which was challenging to work with	1	3	4

The reason for the connection failure or slow integration could be due to slow Wi-Fi speeds encountered while using BPMTouch. Seven out of the eight students indicated that they prefer BPMTouch (touch) over EA (desktop PC) and nine out of the ten industry participants also indicated that they prefer BPMTouch over EA. The reasons why BPMTouch was preferred over EA are documented in Table 6.5. The most frequent theme identified was "*BPMTouch is easier to use*" (f = 7).

Table 6.5: Reasons why BPMTouch was preferred over EA

Challenge	Students Frequency (f)	Industry Frequency (f)	Total
BPMTouch is easier to use	4	3	7
Mobility	0	4	4
It allows for easier collaboration	2	2	4
Faster modelling process	2	0	2

The one student that preferred EA over BPMTouch said that EA is a more powerful tool and until more features are added to BPMTouch and the bugs removed he/she prefers EA over BPMTouch. The one industry participant that prefers EA over BPMTouch said it is because he/she prefers the use of a mouse over touch input as touch technology does not always correctly recognise the input gestures from people with big fingers. The participants were also required to make any other comments about the evaluation or BPMTouch (Table 6.6). As 89% of the participants preferred BPMTouch over EA, it indicates that BPMTouch is an accurate solution, however the accuracy could be improved by enabling the system to save automatically and developing the client to be more stable. The most frequent theme identified in the comments about BPMTouch was "*BPMTouch is a good application*" (f = 3).

Table 6.6: Comments about BPMTouch

Comment	Students Frequency (f)	Industry Frequency (f)	Time
BPMTouch is a good application	2	1	3
Enjoyed using the application	2	0	2
Very good tool if all the bugs can be removed	1	0	1
Typing on a touch screen takes a while to get used to	1	0	1
The client screen should be more stable	0	1	1
The system did not save automatically	0	1	1
Interesting project with useful applications	0	1	1

From the video recordings and observations made by the author during the evaluation sessions it is clear that all the participants coordinated with their partners. They collaborated by working together and communicated by discussing the model and who needed to do what. The participants also helped each other when errors occurred and most of the industry participants coordinated constantly by changing control (flag) to their partners several times throughout the evaluation. From the observation it was clear that the participants enjoyed

several benefits of CBPM and overcame several challenges of CBPM. The features of CBPM that participants enjoyed include:

- Sharing ideas, opinions and different points of view between modellers as the participants discussed the model to be drawn and took each other's opinions into consideration;
- Learning from other modellers especially in terms of using the BPMTouch software tool;
- More accurate modelling since more than one modeller is involved and they reviewed the model before completing the task; and
- Confidence amongst modellers.

The CBPM challenges overcome by participants include:

- Difficulties of integrating and combining different versions of models and model changes as BPMTouch integrates the models automatically;
- Time management (people aspect and technology aspect) as 89% of the groups were able to complete the task quickly with no signs of disagreement between participants or major technology issues;
- Technology constraints with desktop PCs as desktop PCs were not used; and
- Not having multi-touch computers by using a tablet PC which allows for touch input.

6.3. Fulfilment and Analysis of Requirements

The high level objectives, functional requirements and non-functional requirements of BPMTouch were documented in Chapter 4. The high level objectives are that BPMTouch must allow the users to draw BP models, cater for collaboration, support the SIDV collaboration style and it must run on a tablet PC. All of the high level objectives have been met as participants can draw BP models in a collaborative environment on an Android tablet PC and work on their own separate devices, which supports the SIDV collaboration style.

The functional requirements were also met as BPMTouch allows for the creation of BP models by using the BPMN in a collaborative environment where all of the models are updated on connected devices. One modeller at a time is able to edit and draw the model and coordination is built into BPMTouch so that there is a locking mechanism and control can be passed to other modellers so that they can also model on that same diagram. BPMTouch supports collaboration by having built-in client and server capabilities and by displaying

updated, real-time information on all of the connected devices. BPMTouch can be used by multiple users synchronously in a co-located environment.

The main non-functional requirements were met as BPMTouch is efficient, effective and satisfying to use. BPMTouch is efficient as participants indicated that they could complete their tasks efficiently with *positive* mean ratings ($3.63 \leq \mu \leq 4.30$) and based on the time taken to complete the tasks which were all satisfactory (Section 6.2.3). Participants also indicated that *"they could complete their tasks effectively"* ($4.10 \leq \mu \leq 4.50$) and that *"they were satisfied with BPMTouch"* ($4.00 \leq \mu \leq 4.38$) by providing *positive* mean ratings for both of these statements.

The secondary non-functional requirements were also met. It can be deduced that BPMTouch was easy to use since participants ranked BPMTouch as simple and easy to use with mean scores between *neutral* and *positive*. BPMTouch could also be considered as easy to learn as all of the participants decided not to familiarise themselves with the system but instead they started the evaluation straight away and 89% (f = 8) of the teams were able to successfully complete their BPM task. Out of the nine pairs of participants (four student pairs and five industry pairs), eight pairs managed to complete the model in less than half an hour. This indicates that BPMTouch is both efficient and effective and therefore meeting those non-functional requirements. The ninth pair did not complete the model as the BPMTouch crashed. BPMTouch was attractive to use as 89% of the participants preferred BPMTouch over EA and BPMTouch was satisfying to use. Therefore, all of the non-functional requirements of BPMTouch have been met.

BPMTouch allows for collaboration (Figure 6.2) as participants indicated that they were *"able to easily communicate with my team members"* ($4.38 \leq \mu \leq 4.60$), they were *"able to collaborate easily"* ($4.13 \leq \mu \leq 4.50$) and *"all of the team members participated"* ($4.50 \leq \mu \leq 4.70$). Figure 5.5 showed that *"BPMTouch also allows participants to be productive"* ($4.30 \leq \mu \leq 4.38$) as 89% of the teams were able to complete the model quickly. BPMTouch is also *attractive to use* and participants indicated that *"the interface was pleasant"* ($4.25 \leq \mu \leq 4.40$) and they *"liked using the interface"* ($4.40 \leq \mu \leq 4.50$).

According to Activity 5 (evaluation) of the DSR methodology (Section 1.10.2), the objectives defined in Activity 2 (define the objectives of a solution) should be compared to the recorded results. Upon completion of the evaluation, researchers should analyse the results and

determine whether it is necessary to iterate back to Activity 3 (design and development) in order to improve the artefact or if the study can proceed to Activity 6 (communication). From the results of this section it is evident that the objectives and requirements have been met. Therefore the study can proceed to Activity 6.

6.4. Framework for CBPM (Version 2)

The former version of the framework (Chapter 3) included the benefits of BPM and CBPM; the challenges of BPM and CBPM; the success measures of BPM and the CSFs of CBPM. All of these aspects form part of the *BPM Planning Elements* section of the framework. Another section, *Demonstrate and Evaluate*, has been added to the framework based on the successful BPMTouch software tool. This section shows that a BPMTouch software tool needs to be developed (develop a CBPM tool) as it forms part of the framework. Usability criteria should be used to evaluate the tool and to provide feedback on the outcomes of the evaluation.

This updated version of the framework is the final framework for co-located CBPM using touch technologies. The top three benefits, challenges, measures and CSFs have been typed in a different colour. Organisations can take them into consideration before starting a CBPM project. Once these aspects have all been identified and presented to management and have been approved, a CBPM software tool (BPMTouch) is required to carry out the CBPM project. Organisations can purchase a software solution such as BPMTouch or they can develop their own solution in-house. Before the CBPM tool is used for a CBPM project, it needs to be rigorously evaluated and improvements should be made if necessary. This study proposes that if all of the aspects identified in the framework are taken into consideration and followed, organisations will be able to carry out CBPM projects in a co-located environment using touch technologies.

BPM PLANNING ELEMENTS

Identify Benefits of CBPM

Benefits of BPM	Benefits of Collaboration
Understanding	Sharing ideas, opinions and different points of view between modellers
Process improvement	Learning from other modellers
Communication	Increased understanding of the process amongst modellers
Model-driven process execution	Brainstorming amongst modellers
Process performance measurement	More accurate modelling since more than one modeller is involved
	Shared ownership of the process amongst modellers
	Confidence amongst modellers

Affects

Investigate Challenges of CBPM

Challenges of BPM	Challenges of Collaboration
Standardisation	Having different interpretations of the process from each modeller
Modelling level of detail	Difficulties of integrating and combining different versions of models and model changes
Ease of use	Time management – people aspect
Business process modelling expertise	Time management – technical aspect
Model management	Technology constraints with desktop PCs
	Not having multi-touch computers makes collaboration difficult

Affects

Consider Success Measures

User satisfaction
Model use
Effectiveness
Process model quality
Modeller's satisfaction
Efficiency
Ease of use

Analyse CSFs of CBPM

User participation
Time resources
Modellers giving different inputs and interpretations of the processes
Drawing only one diagram and sharing input to that diagram

DEMONSTRATE AND EVALUATE

Evaluate and Feedback

Develop CBPM Tool

CBPM Tool

Usability Criteria

Figure 6.8: Framework for CBPM (version 2)

146

6.5. Conclusion

This chapter was based on Activities 4 and 5 of DSR by demonstrating the software artefact and discussing the evaluation of the artefact. This chapter also answered the sixth research question *(RQ6) "How can software for CBPM be evaluated?"* Criteria for usability evaluations were defined and used to evaluate the BPMTouch system by means of two sets of evaluations. The first set of evaluations was with four pairs of student participants (n = 8) and the second set was with five pairs of industry participants (n = 10). The evaluation results were analysed and discussed.

The most common usability metrics, as identified in Chapter 5, are effectiveness, efficiency and satisfaction (Donyaee 2001). BPMTouch proved to be efficient as the students and industry participants could complete the modelling task in less time than the pilot study participants. Eight out of the nine teams were able to complete the task indicating that BPMTouch is effective and the tasks were completed in less than 30 minutes which indicates that BPMTouch is efficient. All the participants were satisfied with BPMTouch and 89% of the participants prefer BPMTouch over EA. The overall usability results were positive (Table 6.2) with the students giving a *positive* overall usability rating ($\mu = 4.12$) and the industry participants giving a *positive* usability rating ($\mu = 3.92$).

The requirements and objectives of the BPMTouch software solution that were identified in Chapter 4 were revisited in order to determine whether they had been met (Section 6.3). The tasks which were carried out in the evaluation were sufficient to be able to determine whether BPMTouch satisfies all of the outlined objectives and requirements. The results of the evaluations have shown that every objective and requirement was successfully met.

The main research objective (RO_M) of this study is:

> *To design a framework that can be used for co-located collaborative business process modelling (CBPM) using touch technologies.*

RO_M has been met by producing a final framework for co-located CBPM using touch technologies (Section 6.4). The aspects of the framework have been discussed as well as how organisations should make use of the framework. This framework is the main deliverable (artifact) of this study.

147

Chapter 7 is the final chapter and summarises this study. The chapter will review the research objectives and discuss the research contributions, problems experienced and the recommendations for future research.

Chapter 7

Conclusion and Recommendations for Future Research

7.1. Introduction

This study investigated CBPM and how current technologies do not effectively support CBPM. This chapter will discuss the findings from the study and is based on activity 6 of DSR, "Communication" (Chapter 1). In order to determine whether the study was successful, the research objectives need to be reviewed (Section 7.2). The contributions of the study will then be discussed (Section 7.3) and the problems experienced and limitations will also be discussed (Section 7.4). Even though the study was successful, there are still recommendations and possibilities for future research (Section 7.5). Section 7.6 summarises the entire study and Figure 7.1 shows the layout of this chapter.

The main aim of this study was to create and investigate a framework for co-located CBPM using touch technologies. The thesis statement is: "*A framework for co-located collaborative business process modelling using touch technologies can improve the efficiency, effectiveness and user satisfaction of business process modelling activities*".

The main research question for this study is: "*What framework can be used to support co-located collaborative business process modelling using touch technologies?*" and the main Research Objective (RO_M) of this study is: "*To design a framework that can be used for co-located collaborative business process modelling (CBPM) using touch technologies*".

The research problem of this study is that "*modellers experience difficulties conducting collaborative business process modelling activities in a co-located environment*". This research problem was validated by the pilot study, survey for CBPM and the field study. This chapter will discuss the thesis statement, RO_M and the research problem.

Chapter 1	Chapter 2	Chapter 3	Chapter 4	Chapter 5	Chapter 6	**Chapter 7**
Introduction	Business Process Modelling	Problem Identification of Collaborative Business Process Modelling	Objectives of a Collaborative Business Process Modelling Touch Solution (BPMTouch)	Design and Development of the BPMTouch Software Tool	BPMTouch Evaluation	**Conclusion and Recommendations for Future Research**

7.1. Introduction

7.2. Research Objectives Reviewed

7.3. Theoretical and Practical Research Contributions

7.4. Problems Experienced and Limitations

7.5. Recommendations and Future Research

7.6. Summary

Figure 7.1: Chapter 7 layout

7.2. Research Objectives Reviewed

The study had a main research objective and six secondary research objectives (Section 1.5). These research objectives were constructed in order to answer the research questions (Section 1.6). The main research objective of this study is "***To design a framework that can be used for co-located collaborative business process modelling (CBPM) using touch technologies".*** The framework was built based on the secondary research objectives. The framework for co-located CBPM using touch technologies is presented in Figure 7.2.

The first objective was to identify the benefits and challenges of CBPM which was based on activity 1 of DSR, "Identify problem and motivate" (Chapter 1). The primary benefits of BPM are *understanding*, *process improvement* and *communication* (Chapter 2). The theoretical benefits of CBPM were empirically validated in Chapter 3 by means of a survey of South African organisations. The results of the survey showed that benefits of CBPM are the *sharing of ideas, opinions and points of view between modellers*, *learning from other modellers*, *increased understanding* and *brainstorming*. The three highest rated BPM challenges in the industry survey were *standardisation*, *modelling level of detail* and *ease of use*. The top challenges of CBPM, according to the survey participants, were the *different interpretations from each modeller*, *difficulties of integrating and combining different versions of models and model changes*, and *time management* (people aspect). The second objective of this study was to identify the CSFs and the success measures of CBPM. The highest rated CSFs according to the survey were *user participation*, *time resources* and *modellers giving different inputs and interpretations of the processes*. The top measures were *user satisfaction*, *model use* and *effectiveness*. The identified benefits, challenges, CSFs and measures were derived from theory and validated by means of an industry survey. These aspects all form part of the framework (Chapter 3).

The third objective was to identify technologies that can be used for collaboration. The reason for this was so that an appropriate hardware could be identified and used for the software prototype. The software also had to be investigated to ensure that the proposed prototype is not already available on the market. Hardware that can be used for collaboration include multi-touch surfaces, interactive whiteboards, tablet PCs and multiple displays in a single location. The tablet PC was chosen for this particular study as it has many benefits such as mobility and touch.

The fourth objective was to define the objectives and requirements of the software tool (BPMTouch) and this was based on Activity 2 of DSR, "Define objectives of a solution" (Chapter 1). The objectives and requirements were defined in Chapter 4 and include functional and non-functional requirements of BPMTouch. The high level objectives of BPMTouch have been accomplished. The functional and non-functional requirements of BPMTouch are shown in Table 7.1.

Table 7.1: The functional and non-functional requirements of the touch solution for CBPM

Number	Requirements
**Functional Requirements**	
1	The software must support the BPMN
2	The software must allow users to collaborate by updating the models on all of the connected devices (showing up-to-date displays of information)
3	The software must allow for coordination
4	The software should have built-in client and server capabilities
5	Up-to-date information needs to be displayed on all tablets
6	The system must have a built-in locking mechanism
7	The software should allow multiple users to use it in the same place and at the same time (co-located and synchronous)
**Non-functional Requirements**	
8	Efficiency
9	Effectiveness
10	Satisfaction
11	The system must be easy to use
12	The system must be easy to learn
13	The system should be attractive to use

The fifth objective was to identify the usability and design considerations of current CBPM tools so that they can be used for the design of BPMTouch. The design considerations were based on Activity 3 of DSR, "Design and development" (Chapter 1). These design considerations are:

- BPMTouch must be easy to use;
- The interface must be intuitive;
- BPMTouch must allow for modelling;
- It must be user friendly;
- The alignment of objects should not be challenging; and
- Integration should be easy.

The sixth objective was to evaluate a software prototype for CBPM (Chapter 6) and this was based on Activities 4 and 5 of DSR, "Demonstration" and "Evaluation". The purpose of this evaluation was to examine the usability of the prototype as well as to determine whether the prototype could allow for efficient, effective and satisfactory BPM activity, as stated in the thesis statement.

7.3. Theoretical and Practical Research Contributions

The research contributions from this dissertation include both theoretical and practical contributions. DSR (Section 1.10.2) was implemented in the creation of the two major artifacts namely the Framework for CBPM and BPMTouch. The theoretical contributions were identified after a literature study and are:

- Empirically validated benefits of BPM and CBPM (Chapters 2 and 3);
- Empirically validated challenges of BPM and CBPM (Chapters 2 and 3);
- Empirically validated CSFs and success measures for CBPM (Chapters 2 and 3); and
- Investigation of approaches in which touch technology can be used to solve collaboration issues (Chapter 4).

The benefits and challenges of both BPM and CBPM were empirically validated by means of an industry survey which was sent to forty-five industry participants throughout South Africa. The CSFs and success measures of CBPM were also validated by the industry survey. Participants were not required to validate the hardware for collaboration but instead were required to indicate what type of hardware they currently use for BPM.

The empirically validated benefits, challenges CSFs and measures form part of the aspects of CBPM in framework for co-located CBPM using touch technologies, which is a practical contribution of this study. The top three benefits, challenges, measures and CSFs determined from the industry survey are in a colour font (Figure 7.2) to show that companies should take these into consideration before embarking on a CBPM project.

The CBPM tool shown on the framework refers to the software prototype (BPMTouch) that was developed and tested on Samsung Galaxy tablet PCs which run the Android ICS 4.0.4 operating system. The framework was created with BPMTouch in mind; however, the framework can be used for any CBPM software with similar capabilities to BPMTouch.

The requirements for BPMTouch were documented and the design was discussed in Chapter 5. BPMTouch was then evaluated by both students and industry participants with modelling experience in either process modelling or UML modelling or both (Chapter 6). Participants were required to complete a post-test questionnaire consisting of several sections including a usability section which was the PSSUQ usability questionnaire. Many of the BPM and CBPM challenges identified in Chapters 2 and 3, such as *ease of use* and *integration*, were overcome by BPMTouch. Overall, the evaluation of BPMTouch yielded positive results and both students and industry enjoyed working with the software.

The proposed framework (Figure 7.2) provides aspects that should be followed when carrying out a CBPM project. Organisations need to identify the benefits of BPM and collaboration. As a guideline, organisations only need to look at the top three benefits (typed in green) of CBPM. These will provide a clear motivation why to carry out a BPM project and why to do it in a collaborative environment with the relevant stakeholders present.

Organisations should also identify the challenges of CBPM so that they can try to prevent and overcome challenges if they occur. The top three challenges of BPM and collaboration have been typed in blue and should be used by organisations as a clear indication of the possible challenges that can occur. Organisations also need to consider factors for improving the success of CBPM before embarking on a CBPM project. The top CSFs have been typed in orange and the top success measures have been typed in purple. The top CSFs should be put into place before starting the CBPM project.

Once the theoretical aspects have been considered, a CBPM tool (BPMTouch system) needs to be developed in an iterative manner and used if there is not already an existing CBPM touch-based system. In order to develop a satisfactory system, the usability criteria need to be taken into account and the system needs to be evaluated. The feedback received from the evaluations need to be taken into account when making improvements and modifications to the system. Alternatively, the BPMTouch used in this study can be used in a CBPM project and organisations will not have to develop their own CBPM touch solution.
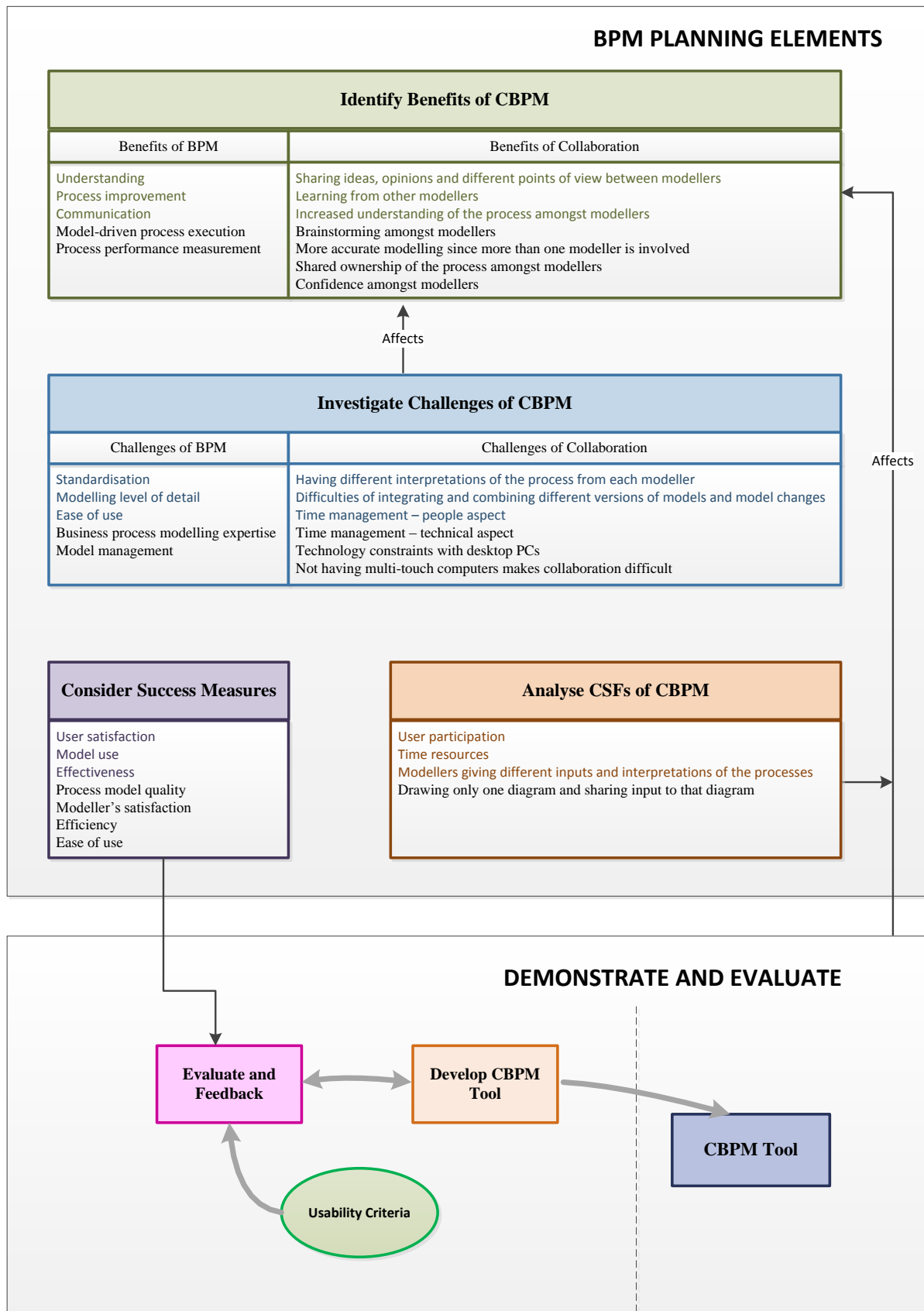
Figure 7.2: Proposed Framework for Co-located CBPM Using Touch Technologies

The thesis statement has been fulfilled and proved:

> *A framework for co-located collaborative business process modelling (CBPM) using touch technologies can improve the efficiency, effectiveness and satisfaction of business process modelling activities.*

BPMTouch is a unique CBPM software solution that enables users to provide touch input using a tablet PC. BPMTouch has built in client-server capabilities that allow participants to synchronously and simultaneously draw a BP model in co-located collaborative environment. BPMTouch handles potential synchronisation problems by means of a locking mechanism so that only one person can edit the model at a time. The models are updated on all of the connected tablet PCs in real-time and each modeller can therefore look at their own model while collaborating with the other modellers. Models are automatically integrated as all of the modellers are working on one version of the BP model at a time.

BPMTouch is effective, efficient and participants found it satisfactory (Chapter 6). Several participants indicated that BPMTouch is easier to use than traditional desktop systems such as EA. Eighty-nine percent of the participants also indicated that they prefer BPMTouch over traditional desktop BPM systems. BPMTouch forms part of the framework for co-located CBPM and therefore the framework for co-located CBPM using touch technologies can improve the efficiency, effectiveness and satisfaction of BPM activities.

7.4. Problems Experienced and Limitations

Several problems were encountered throughout this study. The main problems related to the sample sizes of the participants in the survey and in the evaluations. The BPM survey that was sent out to the industry participants yielded a total of 45 valid responses which were enough for certain statistical tests. Students from the BPM module participated in the field study comprising two assignments which evaluated EA in a collaborative environment (Section 5.2.4). This was a limitation as some of the students never attended the practicals, completed the assignments or completed the post-test questionnaires.

The evaluation of BPMTouch proved to be very challenging as it took place in the second semester when the students had already completed the BPM module and were not interested in taking part in BPM activities any more. The students were also busy with semester tests

and making time for evaluations was not a priority. Eight students (four pairs) volunteered to take part in the evaluation. The industry evaluations were also challenging as most industry participants that were asked to participate responded and said that they were too busy at work and did not have any free time. Ten industry participants (five pairs) volunteered to take part in the BPMTouch evaluation. The 18 participants were sufficient to identify usability problems and to receive feedback, however 40 participants would have been ideal for statistical analysis.

7.5. Recommendations and Future Research

Several practical recommendations can be made to improve the BPMTouch software tool so that the challenges identified in BPMTouch evaluation can be overcome (Section 7.5.1). The BPMTouch software tool forms part of the framework for co-located CBPM using touch technologies which should be followed by organisations wanting to embark on a CBPM project. The framework can also be used by other researchers (Section 7.5.2). This study only scraped the surface of what can be researched in the field of CBPM and there are many possibilities for future research (Section 7.5.3).

7.5.1. Practical Recommendations

 The framework for co-located CBPM can be used by organisations that want to embark on a CBPM project. It is important that organisations know what the benefits of such a project would be in order to justify the time and budgetary constraints. The benefits can be taken into consideration and shared with all of the relevant stakeholders, especially the stakeholders in charge of making the decisions and providing the funding for the CBPM project. The challenges can be taken into consideration so that modellers know what the challenges are ahead of time in order to try to prevent the challenges from occurring instead of trying to overcome them during the project. The CSFs are also very important as these factors should be in place before the project starts in order to increase the success rate of the project. BPMTouch can be used by modellers in a co-located collaborative modelling environment, especially in the initial stages while the processes are being discussed.

7.5.2. Theoretical Recommendations

The framework for co-located CBPM using touch technologies can be used for other research studies relating to co-located CBPM. The framework can assist other researchers by providing them with a concise and accurate summary of past and present research that has been done in the field. Usability researchers can use the usability criteria to evaluate other CBPM studies. BPM researchers can use the CSFs for studies on BPM projects. The coordination, collaboration and communication theories (Section 3.2) can be applied to future research projects that focus on interaction amongst participants in groups.

7.5.3. Future Research

The BPMTouch software should be improved and expanded to include an undo function as participants found the lack of this very frustrating. BPMTouch could also be improved to work with a multi-touch surface and several tablet PCs so that it can be used in a multi-display environment in which the facilitator can work on the multi-touch surface. Ideally, it would be good if each participant can lock part of a model and make changes to their own part, simultaneously, and the changes are then updated in the original model. This would mean that more than one modeller has the opportunity to model at a time and other modellers do not have to sit and watch one person model.

BPMTouch can also be improved to allow for dispersed collaboration so that modellers can discuss the model in a co-located environment and then go back to their offices and complete the model individually while still collaborating. Cloud computing would also be an interesting topic combined with CBPM and BPMTouch so that the models are stored in the cloud instead of a tablet PC acting as a server. This would make models accessible from anywhere and the entire solution more mobile.

BPMTouch could be improved so that the updates to the client tablets are quicker and so that all participants receive a notification when a change has been made to the model. The notification should indicate that a change has been made, who made the change and what exactly the change entails. It would also be pleasant if an "accept" and a "reject" function, similar to that of COMA tool (Chapter 3) was implemented.

CBPM in general could be researched further by carrying out case studies in organisations with large modelling teams. This would allow the researcher to identify exactly what happens

in a modelling session which could build on the recommended framework. The framework can also be evaluated and built on in future studies. This study can also be taken further to investigate and evaluate larger sample sizes from HEIs and industry in order to acquire more results that can be statistically analysed. CBPM is a growing field in South Africa as organisations need to carry out BPM activities before implementing new software solutions and to optimise their companies' processes.

7.6. Summary

This study has produced two artifacts while following the DSR methodology, namely:

- The BPMTouch software application; and
- The framework for co-located CBPM using touch technologies.

The framework should be used by organisations who want to embark on a CBPM project as it contains aspects that should be taken into consideration before a CBPM project is started. The aspects are: identify the benefits of CBPM, investigate the challenges of CBPM, consider the success measures and analyse CSFs for CBPM. The benefits will be useful to present to a board of directors in order to gain buy-in from top management. The challenges need to be identified so that strategies can be put in place to overcome them. The CSFs and success measures need to be taken into consideration and the CSFs need to be in place before the project is started to increase the chances of CBPM project success. The framework also shows that a CBPM tool needs to be developed and evaluated with appropriate usability criteria. This is an iterative activity, until the appropriate tool is produced. Alternatively, the BPMTouch tool developed by the author could be used by the organisation.

The BPMTouch tool caters for collaboration by allowing participants to work together synchronously on a model in a co-located environment. All participants can see the changes being made to the model on their own separate devices, however, only one participant can edit the model at a time. A major benefit of BPMTouch is that it eliminates the integration factor and participants therefore do not have to worry about integrating their models as this is done automatically.

BPMTouch was successfully evaluated by both student and industry participants. The results showed that both the students and the industry participants preferred BPMTouch over a traditional BPM tool such as EA.

- - - - - End - - - - -

References

ABPMP, 2013. Association of Business Process Management Professionals. Available at: http://www.abpmp.org/index.cfm [Accessed April 16, 2013].

AccuProcess, 2009. Five Key Benefits of Business Process Modeling. Available at: http://www.accuprocess.com/documentation/WP-5_Benefits_of_Business_Process_Modeling.pdf [Accessed November 25, 2012].

AccuProcess, 2013. Process Modeler. Available at: http://www.accuprocess.com/products/process-modeler.html [Accessed June 17, 2013].

Aleem, S., Lazarova-Molnar, S. and Mohamed, N., 2012. Collaborative Business Process Modeling Approaches: A Review. In *IEEE 21st International Workshop on Enabling Technologies: Infrastructure for Collaborative Enterprises*. Washington D.C., Washington, USA: IEEE Computer Society, pp. 274–279.

ALTOVA, 2013. UModel - UML Tool for Software Modeling and Application Development. Available at: http://www.altova.com/umodel.html [Accessed June 17, 2013].

Amalnick, M., Ansarinejad, A., Ansarinejad, S. and Hatami-Shirkouhi, L., 2010. A Group Decision Making Approach for Evaluation of ERP Critical Success Factors Using Fuzzy AHP. In D. Al-Dabass, A. Orsoni, A. Pantelous, M. Vannucci, and A. Abraham, eds. *2010 Fourth UKSim European Symposium on Computer Modeling and Simulation*. Pisa, Italy: IEEE Computer Society, pp. 212–217.

Apted, T. and Kay, J., 2008. PhoTable: Enhancing the Social Interaction around the Sharing of Digital Photographs. In *CHI 08 workshop on Collocated social practices surrounding photos*.

Bandara, W., Gable, G. and Rosemann, M., 2005. Factors and measures of business process modelling: model building through a multiple case study. *European Journal of Information Systems*, 14(4), pp. 347–360.

Barjis, J., 2009. Collaborative, Participative and Interactive Enterprise Modeling. In J. Filipe and J. Cordeiro, eds. *Enterprise Information Systems*. Milan, Italy: Springer Berlin Heidelberg, pp. 651–662.

Barjis, J., 2011. CPI Modeling: Collaborative, Participative, Interactive Modeling. In S. Jain, R. Creasey, and J. Himmelspach, eds. *Proceedings of the 2011 Winter Simulation Conference*. Grand Arizona Resort Phoenix, USA: IEEE Computer Society, pp. 3094–3103.

Becta ICT Research, 2004. Getting the most from your interactive whiteboard: A guide for secondary schools. Available at: https://www.education.gov.uk/publications/standard/_arc_Subjects/Page9/15091 [Accessed April 6, 2013].

Benavent, A.P., Belmonte, F.N. and Bonastre, O.M., 2006. Pedagogical Use of Tablet PC for Active and Collaborative Learning. In *2006 IEEE International Professional Communication Conference*. Saratoga Springs, New York, USA: IEEE Computer Society, pp. 214–218.

Berry, M. and Hamilton, M., 2006. Mobile Computing, Visual Diaries, Learning and Communication: Changes to the Communicative Ecology of Design Students Through Mobile Computing. In D. Tolhurst and S. Mann, eds. *Proceedings of the Eighth Australasian Computing Education Conference (ACE2006)*. Hobart, Australia: CRPIT, pp. 35–44.

Biehl, J.T., Baker, W.T., Bailey, B.P., Tan, D.S., Inkpen, K.M. and Czerwinski, M., 2008. IMPROMPTU: A New Interaction Framework for Supporting Collaboration in Multiple Display Environments and Its Field Evaluation for Co-located Software Development. In M. Czerwinski, K. Lund, and D.S. Tan, eds. *Conference on Human Factors in Computing Systems (CHI 2008)*. Florence, Italy: Association for Computing Machinery, Inc., pp. 939–948.

Bizagi, 2013. Bizagi Process Modeler. Available at: http://www.bizagi.com/index.php?option=com_content&view=article&id=335&Itemid=267&lang=en [Accessed June 17, 2013].

Brandford, R., 2012. Tablets in the enterprise: Challenges of office mobility. Available at: http://www.computerweekly.com/feature/Challenges-of-office-mobility [Accessed April 5, 2013].

Bryman, A., 2012. *Social Research Methods* 4th ed., New York: Oxford University Press Inc.

BusinessTech, 2013a. Tablets vs PCs in SA. Available at: http://businesstech.co.za/news/hardware/30079/tablets-vs-pcs-in-sa/ [Accessed April 4, 2013].

BusinessTech, 2013b. Tablet sales are booming. Available at: http://businesstech.co.za/news/mobile/36994/tablet-sales-are-booming/ [Accessed November 13, 2013].

Chiorean, D., Ober, I. and Petrascu, V., 2011. Avoiding OCL Specification Pitfalls. In T. Margaria, J. Padberg, G. Taentzer, M. Brandsteidl, and A. Winter, eds. *7th Educators' Symposium @ MODELS 2011: Software Modeling in Education (EduSymp2011)*. Wellinton, New Zealand: Springer-Verlag Berlin, pp. 7–16.

Clifton, P., Mazalek, A. and Sanford, J., 2011. SketchTop: design collaboration on a multi-touch tabletop. In *Proceedings of the fifth international conference on Tangible, embedded, and embodied interaction*. Funchal, Portugal: ACM Press, pp. 333–336.

Combemale, B., Cregut, X., Dieumegard, A., Pantel, M. and Faiez, Z., 2011. Teaching MDE Through the Formal Verification of Process Models. In M. Brandsteidl and A. Winter, eds. *Educators' Symposium @ MODELS,* Wellinton, New Zealand: University of Oldenburg, pp. 17–26.

Creswell, J.W., 2009. *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches* 3rd ed., Los Angeles, California, USA: SAGE Publications.

DASIK, 2012. DASIK. Available at: http://dasik.org [Accessed October 12, 2013].

Data Analysis Australia, 2013. What Are You Really Measuring? Reliability and Validity in Questionnaire Design. Available at: http://www.daa.com.au/analytical-ideas/questionnaire-validity/ [Accessed November 3, 2013].

Davies, I., Green, P., Rosemann, M., Indulska, M. and Gallo, S., 2006. How do practitioners use conceptual modeling in practice? *Data & Knowledge Engineering*, 58(3), pp. 358–380.

Dayal, U., Hsu, M. and Rivka, L., 2001. Business process coordination: State of the art, trends, and open issues. In *Proceedings of the 27th VLDB Conference*. Roma, pp. 9–13.

Denise, L., 2010. Collaboration vs. C-Three (Cooperation, Coordination, and Communication). *Innovating*, 7(3), pp. 1–6.

Derizemlya, Y., 2009. Microsoft Surface: Advantages and Disadvantages. Available at: http://yderizem.blogspot.com/2009/10/google-chrome-advantages-and.html [Accessed October 23, 2013].

Dollmann, T., Houy, C., Fettke, P. and Loos, P., 2011. Collaborative Business Process Modeling with CoMoMod - A Toolkit for Model Integration in Distributed Cooperation Environments. In S. Reddy and S. Tata, eds. *2011 IEEE 20th International Workshops on Enabling Technologies: Infrastructure for Collaborative Enterprises*. Paris, France: IEEE Computer Society, pp. 217–222.

Donyaee, M.K., 2001. *Towards an Integrated Model for Specifying and Measuring Quality in Use*. Concordia University.

Dreiling, A., 2009. Gravity - Collaborative Business Process Modelling withing Google Wave. Available at: http://scn.sap.com/people/alexander.dreiling/blog/2009/09/02/gravity-collaborative-business-process-modelling-within-google-wave [Accessed November 12, 2013].

Ellis, C.A., Gibbs, S.J. and Rein, G.L., 1991. Groupware: some issues and experiences. *Communications of the ACM*, 34(1), pp. 39–58.

Fotini, M., Anthi-Maria, S. and Euripidis, L., 2008. ERP Systems Business Value: A Critical Review of Empirical Literature. In *Proceedings of the 2008 Panhellenic Conference on Informatics*. Samos Island, Greece: IEEE Computer Society, pp. 186–190.

Garay, A.W., 2012. The Top 10 Business Analysis Skills for 2012. Available at: http://www.batimes.com/angela-wick/the-top-10-business-analysis-skills-for-2012.html [Accessed October 28, 2013].

García, J.G., Vanderdonckt, J., Lemaige, C. and Calleros, J.M.G., 2008. How to Describe Workflow Information Systems to Support Business Process. In B. Werner, ed. *2008*

10th IEEE Conference on E-Commerce Technology and the Fifth IEEE Conference on Enterprise Computing, E-Commerce and E-Services. San Francisco, California, USA: IEEE Computer Society, pp. 404–411.

Georgakopoulos, D., Hornick, M. and Sheth, A., 1995. An overview of workflow management: From process modeling to workflow automation infrastructure. *Distributed and Parallel Databases*, 3(2), pp. 119–153.

Gibbs, G.R., 2007. *Analyzing Qualitative Data*, London, England: SAGE Publications Ltd.

Grosskopf, A., Edelman, J. and Weske, M., 2010. Tangible Business Process Modeling - Methodology and Experiment Design. In S. Rinderle-Ma, S. Sadiq, and F. Leymann, eds. *Business Process Managment Workshops*. Germany: Springer-Verlag Berlin, pp. 489–500.

Grossmann, G., Schrefl, M. and Stumptner, M., 2008. Modelling Inter-Process Dependencies with High-Level Business Process Modelling Languages. In M. Kirchberg and S. Link, eds. *Asia-Pacific Conference on Conceptual Modelling (APCCM)*. Wollongong, New South Wales, Australia: Australian Computer Society 2009, pp. 89–102.

Grudin, J., 1994. Computer-supported cooperative work: History and focus. *Computer*, 27(5), pp. 19–26.

Hammer, M., 2010. What is Business Process Management? In J. Brocke and M. Rosemann, eds. *Handbook on Business Process Management 1*. Cambridge, Massachusetts, USA: Springer Berlin Heidelberg, pp. 3–16.

Hammer, M. and Champy, J., 1993. *Reengineering the Corporation: A Manifesto for Business Revolution* 2nd ed., New York, New York, USA: Harper Collins Publishers.

Harmon, P., 2007. *Business Process Change: A Guide for Business Managers and BPM and Six Sigma Professionals* 2nd ed., San Francisco, California, USA: Morgan Kaufmann Publishers.

Harmon, P. and Wolf, C., 2011. Business Process Modeling Survey, (December). Available at: http://www.bptrends.com/members_surveys/deliver.cfm?report_id=1005&target=Process_Modeling_Survey-Dec_11_FINAL.pdf&return=surveys_landing.cfm [Accessed August 20, 2012].

Havey, M., 2005. *Essential business Process Modeling*, Salt Lake City: O'Reilly Media.

Hein, R., 2013. 16 IT Skills in High Demand in 2013. Available at: http://www.cio.com/slideshow/detail/119877#slide13 [Accessed October 28, 2013].

Hevner, A. and Chatterjee, S., 2010. *Design Research in Information Systems*, London: Springer Berlin.

Hevner, A.R., March, S.T., Park, J. and Ram, S., 2004. Design science in information systems research. *MIS quarterly*, 28(1), pp. 75–105.

Hinckley, K., 2003. Synchronous gestures for multiple persons and computers. In *Proceedings of the 16th annual ACM symposium on User interface software and technology*. Vancouver, BC, Canada: ACM Press, pp. 149–158.

Hinckley, K., Ramos, G. and Guimbretiere, F., 2004. Stitching: pen gestures that span multiple displays. In M. F. Costabile, ed. *Proceedings of the working conference on Advanced visual interfaces*. Gallipoli, Italy: ACM Press, pp. 23–31.

Hollingsworth, D., 1994. Workflow management coalition: The workflow reference model. *Workflow Management Coalition*, 1(1), p. 68.

Hornecker, E., Marshall, P., Dalton, N.S. and Rogers, Y., 2008. Collaboration and Interference: Awareness with Mice or Touch Input. In *Proceedings of the ACM 2008 conference on Computer supported cooperative work - CSCW '08*. Gramado, Brazil: ACM Press, pp. 167–176.

Hunter, S. and Maes, P., 2008. WordPlay: A table-top interface for collaborative brainstorming and decision making. In *Proceedings of IEEE Tabletops and Interactive Surfaces*. Amsterdam, The Netherlands: IEEE Computer Society, pp. 2–5.

Hutchings, D.R., Stasko, J. and Czerwinski, M., 2005. Distributed display environments. In *CHI '05 extended abstracts on Human factors in computing systems - CHI '05*. Portland, OR, USA: ACM Press, p. 2117.

Hwang, G.W., Wu, C.H. and Kuo, F.R., 2013. Effects of Touch Technology-based Concept Mapping on Students' Learning Attitudes and Perceptions. *Educational Technology & Society*, 16(3), pp. 274–285.

IBM, 2013. Why WebSphere Software. Available at: http://www-01.ibm.com/software/websphere/?lnk=mprSO-webs-usen [Accessed November 2, 2013].

Indulska, M., Green, P., Recker, J. and Rosemann, M., 2009a. Business process modeling: perceived benefits. In *28th International Conference on Conceptual Modeling*. Gramado, Brazil: ACM, pp. 9–12.

Indulska, M., Recker, J.C., Rosemann, M. and Green, P., 2009b. Process Modeling : Current Issues and Future Challenges. In P.A.T. van Eck, J. Gordijn, and R. J. Wieringa, eds. *21st International Conference on Advanced Information Systems*. Amsterdam, The Netherlands: Springer Berlin Heidelberg, pp. 8–12.

Inkpen, K.M. and Mandryk, R.L., 2005. Multi-display environments for co-located collaboration. *Position paper for the CHI 2005 Distributed Display Environments workshop*, pp. 1–2.

Institute for Digital Research and Education, 2013. SPSS FAQ. What does Cronbach's alpha mean? Available at: http://www.ats.ucla.edu/stat/spss/faq/alpha.html [Accessed June 8, 2013].

Isenberg, P., Fisher, D., Morris, M.R., Inkpen, K. and Czerwinski, M., 2010. An exploratory study of co-located collaborative visual analytics around a tabletop display. In A.

MacEachren and S. Miksch, eds. *2010 IEEE Symposium on Visual Analytics Science and Technology (VAST)*. Salt Lake City, Utah, USA: IEEE, pp. 179–186.

ISO, 2000. ISO/IEC FDIS 9126-1, 2000. Available at: http://www.iso.org/iso/catalogue_detail.htm?csnumber=22749 [Accessed July 10, 2013].

ISO, 2008. ISO/IEC CD 25010: Software engineering – Software product Quality Requirements and Evaluation (SQuaRE) – Software and quality in use models, (Resolution 937), p. 42.

ITBusinessEdge, 2012. The 10 Most In-Demand IT Job Titles. Available at: http://www.itbusinessedge.com/slideshows/top-10-most-in-demand-it-job-titles-06.html [Accessed October 28, 2013].

Jin, T., Wang, J., Wu, N., La Rosa, M. and ter Hofstede, A.H.M., 2010. Efficient and Accurate Retrieval of Business Process Models through Indexing. In R. Meersman, T. Dillon, and P. Herrero, eds. *On the Move to Meaningful Internet Systems: OTM 2010*. Hersonissos, Crete, Greece: Springer Berlin Heidelberg, pp. 402–409.

Johannesson, P. and Perjons, E., 2012. *A Design Science Primer*, Lexington: CreateSpace.

Kammer, D., Wojdziak, J., Keck, M., Groh, R. and Taranko, S., 2010. Towards a Formalization of Multi-touch Gestures. In *ACM International Conference on Interactive Tabletops and Surfaces*. Saarbrücken, Germany: ACM, pp. 49–58.

Keinonen, T., 1998. *One-dimensional Usability: Influence of Usability on Consumers' Product Preference*, Helsinki: University of Art and Design.

Kershner, R. and Warwick, P., 2006. Replacement or transformation? Teacher research into learning processes associated with interactive whiteboard use in primary classrooms. In *British Educational Research Association Annual Conference*. Warwick: British Educational Research Association (BERA), pp. 1–26.

Ko, R.K.L., 2009. A Computer Scientist's Introductory Guide to Business Process Management (BPM). *Crossroads*, 15(4), pp. 11–18.

Lee, J.D., Hickey, A.M., Zhang, D., Santanen, E. and Zhou, L., 2000. ColD SPA: a tool for collaborative process model development. In *Proceedings of the 33rd Hawaii International Conference on System Sciences*. Hawaii: IEEE, pp. 1–10.

Lewis, J., 1992. Psychometric evaluation of the post-study system usability questionnaire: The PSSUQ. *Proceedings of the Human Factors and Ergonomics Society Annual Meeting*, 36(16), pp. 1259–1263.

Lewis, J., 2002. Psychometric Evaluation of the PSSUQ Using Data from Five Years of Usability Studies. *International Journal of Human-Computer Interaction*, 14(3), pp. 463–488.

Lewis, J.R., 1995. IBM computer usability satisfaction questionnaires: Psychometric evaluation and instructions for use. *International Journal of Human-Computer Interaction*, 7(1), pp. 57–78.

Lindsay, A., Downs, D. and Lunn, K., 2003. Business processes—attempts to find a definition. *Information and Software Technology*, 45(15), pp. 1015–1019.

Marsan, C.D., 2009. Top 10 Technology Skills. Available at: http://www.networkworld.com/news/2009/040609-10-tech-skills.html [Accessed October 1, 2013].

McSweeney, A., 2010. Introduction to Business Process Management, p. 551. Available at: http://www.slideshare.net/alanmcsweeney/introduction-to-business-process-management [Accessed April 16, 2013].

Microsoft, 2013. Visio Top Features. Available at: http://office.microsoft.com/en-us/visio/microsoft-visio-2013-top-features-diagram-software-FX103796044.aspx [Accessed October 21, 2013].

Mochal, T., 2008. 10 Techniques for Gathering Requirements. Available at: http://www.techrepublic.com/blog/10things/10-techniques-for-gathering-requirements/287 [Accessed October 24, 2013].

Nacenta, M.A., Sallam, S., Champoux, B., Subramanian, S. and Gutwin, C., 2006. Perspective cursor: perspective-based interaction for multi-display environments. In *Conference on Human Factors in Computing Systems 2006*. Montreal, Quebec, Canada: ACM Press, p. 289.

Nardi, B.A., Schiano, D.J. and Gumbrecht, M., 2004. Blogging as social activity, or, would you let 900 million people read your diary? In J. Herbsleb and G. Olson, eds. *Proceedings of the 2004 ACM conference on Computer supported cooperative work - CSCW '04*. Chicago, Illinois, USA: ACM Press, p. 222.

Nielsen, J., 1993. Usability engineering. Available at: http://scholar.google.com/scholar?hl=en&btnG=Search&q=intitle:Usability+Engineering#0 [Accessed July 3, 2013].

Nielsen, J., 1994. Estimating the number of subjects needed for a thinking aloud test. *International Journal of Human-computer Studies*, 41(1), pp. 385–397.

Nielsen, J., 2000. Why You Only Need to Test with 5 Users. Available at: http://www.nngroup.com/articles/why-you-only-need-to-test-with-5-users/ [Accessed October 23, 2013].

Nielsen, J., 2012. How Many Test Users in a Usability Study? Available at: http://www.nngroup.com/articles/how-many-test-users/ [Accessed October 23, 2013].

Nielsen, J. and Molich, R., 1990. Heuristic Evaluation of User Interfaces. In J. Carrasco and J. Whiteside, eds. *Proceedings of the SIGCHI conference on Human factors in computing systems*. Seattle, Washington, USA: ACM, pp. 249–256.

NMMU, 2013. Nelson Mandela Metropolitan University. Available at: http://www.nmmu.ac.za/Courses-on-offer/Degrees,-diplomas---certificates/Details.aspx?appqual=PO&qual=20099&faculty=1200 [Accessed October 15, 2013].

Nolan, K.K., 2008. SMARTer Music Teaching: Interactive Whiteboard Use in Music Classrooms. *General Music Today*, 22(2), pp. 3–11.

Northcote, M., Mildenhall, P., Marshall, L. and Swan, P., 2010. Interactive whiteboards : Interactive or just whiteboards? *Australasian Journal of Educational Technology*, 26(4), pp. 494–510.

Nunnally, J.C., 1978. *Psychometric Theory* 2nd ed., New York: McGraw-Hill.

Object Management Group, 1999. OMG Unified Modeling Language Specification, (June). Available at: http://www.informatik.uni-kiel.de/~wg/Lehre/Vorlesung-WS2001-02/UML/UML-Spezifikation.pdf [Accessed October 12, 2012].

Object Management Group, 2008. Welcome to BPMI.org. Available at: http://www.bpmi.org/ [Accessed January 13, 2003].

Object Management Group, 2012. OMG Unified Modeling Language, (October 2012). Available at: http://www.omg.org/spec/UML/2.5/Beta1/PDF/ [Accessed October 12, 2012].

Ottensooser, A., Fekete, A., Reijers, H.A., Mendling, J. and Menictas, C., 2012. Making sense of business process descriptions: An experimental comparison of graphical and textual notations. *Journal of Systems and Software*, 85(3), pp. 596–606.

Oxford University Press, 2013a. Oxford Advanced Learner's Dictionary. Available at: http://oald8.oxfordlearnersdictionaries.com/dictionary/framework [Accessed October 2, 2013].

Oxford University Press, 2013b. Oxford Dictionaries. Available at: http://oxforddictionaries.com/ [Accessed March 24, 2013].

Payton, B., 2007. Review: Sparx Enterprise Architect Professional 6.5. Available at: http://it.toolbox.com/blogs/paytonbyrd/review-sparx-enterprise-architect-professional-65-16300 [Accessed September 10, 2013].

Peffers, K., Tuunanen, T., Rothenberger, M.A. and Chatterjee, S., 2007. A Design Science Research Methodology for Information Systems Research. *Journal of Management Information Systems*, 24(3), pp. 45–77.

Poppe, E., Brown, R.A., Recker, J.C. and Johnson, D.M., 2011. A Prototype Augmented Reality Collaborative Process Modelling Tool. In *9th International Conference on Business Process Management*. Clermont-Ferrand, France, pp. 1–5.

Rafi, S.M., Rao, K.N., Setty, S.P. and Akthar, S., 2012. Joint effect of Learning and Testing Effort in SRGM with Fault Dependent Correction Delay. *International Journal of Computer Science and Information Technologies*, 3(5), pp. 4961–4967.

Rama, J. and Bishop, J., 2006. A survey and comparison of CSCW groupware applications. In *SAICSIT '06*. ACM Press, pp. 198–205.

Ramburn, A., Seymour, L. and Gopaul, A., 2013. Learning from a failed ERP implementation : The case of a large South African organization. In P. Lech, ed. *Proceedings of the European Conference on Information Management 2013*. Gdansk,Poland: Academic Conferences and Publishing International Limited Reading, pp. 215–222.

Renger, M., Kolfschoten, G.L. and de Vreede, G., 2008. Using Interactive Whiteboard Technology to Support Collaborative Modeling. In R. Briggs, P. Antunes, G. Jan de Vreede, and A. Read, eds. *Groupware: Design, Implementation and Use: 14th International Workshop*. Omaha, Nebraska, USA: Springer Berlin Heidelberg, pp. 356–363.

Rittgen, P., 2008. COMA: A Tool for Collaborative Modeling. In *Proceedings of the Forum at the CAiSE'08 Conference*. Montpellier, France: ResearchGate, pp. 61–64.

Rubin, J. and Chisnell, D., 2008. *Handbook of Usability Testing* 2nd ed., Indianapolis, Indiana: Wiley Publishing.

Ryu, K. and Yücesan, E., 2007. CPM: A collaborative process modeling for cooperative manufacturers. *Advanced Engineering Informatics*, 21(2), pp. 231–239.

Sams, I., Wesson, J. and Vogts, D., 2011. An Architecture to Support Multi-Touch Collaborative Information Retrieval. In *Proceedings of the South African Institute for Computer Scientists and Information Technologists Conference*. East London, SA: ACM.

Satzinger, J.W., Jackson, R.B. and Burd, S.D., 2011. *Systems Analysis and Design in a Changing World* 6th ed., Boston, Massachusetts, USA: Cengage Learning.

Saunders, M., Lewis, P. and Thornhill, A., 2009. *Research Methods for Business Students* 5th ed., Sussex: Pearson Education Limited.

Sauro, J., 2011. 10 Essentail Usability Metrics. Available at: http://www.measuringusability.com/blog/essential-metrics.php [Accessed January 28, 2013].

Sauro, J. and Lewis, J., 2012. *Quantifying the User Experience: Practical Satistics for User Research*, Waltham, Massachusetts, USA: Morgan Kaufmann Publishers.

Schwalbe, K., 2013. *Managing Information Technology Projects* 7th ed., Boston, Massachusetts: Thompson Course Technology.

Scott, S., Sheelagh, M. and Carpendale, T., 2004. Territoriality in collaborative tabletop workspaces. In J. Herbsleb and G. Olson, eds. *CSCW '04 Proceedings of the 2004 ACM conference on Computer supported cooperative work*. Chicago, Illinois, USA: ACM Press, pp. 294–303.

Sedera, W., Gable, G., Rosemann, M. and Smyth, R., 2004. A success model for business process modeling: findings from a multiple case study. In P. Seddon and S. Gregor, eds. *8th Pacific Asia Conference on Information Systems*. Shanghai, China: ACM Press, pp. 485–498.

Seethamraju, R., 2010. Business Process Management – A Missing Link in Business Education Business. In M. Santana, J. Luftman, and A. Vinze, eds. *Americas Conference on Information Systems*. Lima, Peru: Association for Information Systems 2010, p. 10.

Seffah, A., Donyaee, M., Kline, R.B. and Padda, H.K., 2006. Usability measurement and metrics: A consolidated model. *Software Quality Journal*, 14(2), pp. 159–178.

Shah, C., 2010. Working in Collaboration - What , Why , and How ? In *Collaborative Information Seeking (CIS) CSCW 2010*. Savannah, Georgia, USA: ACM Press, pp. 1–6.

Snyman, I., 2011. *Visualisation of a Data Cube on a Multi-touch Surface*. Honours Project, Department of Computing Sciences, Nelson Mandela Metropolitan University (NMMU).

Sonteya, T. and Seymour, L., 2012. Towards an Understanding of the Business Process Analyst : An Analysis of Competencies. *Information Technology Education: Research*, 11(1), p. 21.

Sparx Systems, 2013a. Enterprise Architect 10 Reviewer's Guide, p. 33.

Sparx Systems, 2013b. Visual Modeling Platform. Available at: http://www.sparxsystems.com/products/ea/index.html [Accessed May 29, 2013].

Statistics.com, 2013. Golssary of Statistical Terms. Available at: http://www.statistics.com/index.php?page=glossary&term_id=733 [Accessed November 3, 2013].

SYSPRO, 2013. ERP Business Process Management (BPM). Available at: http://www.syspro.com/product/process-management [Accessed October 28, 2013].

Tabtou Ltd., 2012. ProcessCraft - A BPMN 2.0 Visual Editor. Available at: http://showgen.com/#extensive-context-sensitive-help [Accessed July 17, 2013].

Talend, 2013. 10 Best Practices for BPM Implementation, pp. 1–12. Available at: http://info.talend.com/rs/talend/images/wp_en_bpm_10_best_practices.pdf [Accessed October 28, 2013].

Technology Evaluation Centers, 2013. ERP for Process Manufacturing Buyer 's Guide, (May). Available at: http://www.technologyevaluation.com/view_document/report/34885/tec-2013-erp-buyer-s-guide-for-process-manufacturing.html [Accessed September 6, 2013].

Tse, E., Shen, C., Greenberg, S. and Forlines, C., 2007. How pairs interact over a multimodal digital table. *Proceedings of the SIGCHI conference on Human factors in computing systems - CHI '07*, p. 215.

Twidale, M.B. and Nichols, D.M., 1996. *Collaborative Browsing and Visualisation of the Search Process*. Lanchester University.

Twinning, P., Evans, D., Cook, D., Ralston, J., Selwood, I., Jones, A., Underwood, J., Dillon, G., Scanlon, E., Heppell, S., Kukulska-Hulme, A., McAndrew, P. and Sheehy, K., 2005. Tablet PCs in schools. Available at: http://dera.ioe.ac.uk/1461/1/becta_2005_tabletpcs_litrev.pdf [Accessed April 6, 2013].

Virzi, R.A., 1992. Refining the test phase of usability evaluation: how many subjects is enough? *Human Factors - Special Issue: Measurement in Human Factors*, 34(4), pp. 457–468.

Wand, Y. and Weber, R., 2002. Research Commentary: Information Systems and Conceptual Modeling - A Research Agenda. *Information Systems Research*, 13(4), p. 363.

Webster's Online Dictionary, 2012. Webster's Online Dictionary. Available at: http://www.websters-online-dictionary.org/ [Accessed April 27, 2012].

Weske, M., 2012. *Business Process Management: Concepts, Languages, Architectures* 2nd ed., Potsdam, Germany: Springer Berlin Heidelberg.

White, S.A., 2004a. Business Process Modeling Notation. Available at: http://www.omg.org/bpmn/Documents/BPMN_V1-0_May_3_2004.pdf [Accessed September 25, 2012].

White, S.A., 2004b. Introduction to BPMN. *IBM Cooperation*. Available at: http://www.bptrends.com/resources_publications.cfm?publicationtypeID=DFC61D66-1031-D522-3EBDAB1F65A451AA [Accessed June 12, 2012].

Whitney, L., 2013. Lenove, smartphone dark horse? Its shipments surge 78%. Available at: http://news.cnet.com/8301-1001_3-57611264-92/lenovo-smartphone-dark-horse-its-shipments-surge-78/#! [Accessed November 13, 2013].

Whittle, J. and Hutchinson, J., 2011. Mismatches Between Industry Practice and Teaching of Model-driven Software Development, pp. 27–30.

Whittle, J. and Hutchinson, J., 2012. Mismatches Between Industry Practice and Teaching of Model-driven Software Development. In J. Kienzle, ed. *Models in Software Engineering*. Lanchester: Springer Berlin Heidelberg, pp. 40–47.

Yanhong, Z., 2009. ERP Implementation Process Analysis Based on the Key Success Factors. In *Information Technology and Applications*. Fukuoa, Japan: IEEE Computer Society, pp. 25–27.

Appendix A - Biographical Questionnaire

Nelson Mandela Metropolitan University

Department of Computing Sciences

This questionnaire is part of research towards a MCom in Computer Science and Information Systems

Contact Information: Email: Irene.snyman@nmmu.ac.za

Biographical Information

1. *Age*

18 – 25	☐	26 - 35	☐	36 - 45	☐	> 46	☐

2. *Number of years' experience with computers*

< 1	☐	1 - 5	☐	6 - 10	☐	> 10	☐

3. *Male or Female*

Male	☐	Female	☐

4. *Number of years' experience with multi-touch devices*

< 1	☐	1 - 5	☐	6 - 10	☐	> 10	☐

5. *Number of years' experience with business process modelling (BPM) and business process concepts.*

< 1	☐	1 - 5	☐	6 - 10	☐	> 10	☐

6. **Other Biographical Questions**

	Strongly Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Strongly Agree	Not Applicable
	1	2	3	4	5	N/A
You understand the concept of a business process.						
You understand the concept of business process modelling.						
You understand the concept of workflow.						
You know how to create business process modelling diagrams.						
You have worked in a collaborative environment for BPM.						
You have used a multi-touch device.						

Appendix B - Survey for CBPM

Nelson Mandela Metropolitan University

for tomorrow

Business Process Modelling (BPM) Survey

Page:	1

The purpose of this survey is to gather data from organisations to find out what they are doing in terms of business process modelling and workflow. The data gathered from this survey will be used anonymously to contribute towards the design of a framework for co-located collaborative business process modelling. The framework will be used to aid groups of people to conduct process modelling activities simultaneously in a co-located environment. The data collected from this survey will be treated as strictly confidential. The data will not be used for any other purpose than for conducting the research and writing the dissertation for academic purposes only. The results will be displayed anonymously and no participant's identity will be revealed. Your cooperation and time to participate in this survey is greatly appreciated. Note: This is a confidential questionnaire. Your identity will not be revealed. Your willingness to participate is most appreciated. Feedback will be provided to all participants upon request. This research is being conducted in fulfilment of the requirements for the degree Magister Commercii (100% research) in Computing Sciences at Nelson Mandela Metropolitan University. The financial assistance by the NRF and NMMU Master's bursaries towards this research is hereby acknowledged. The opinions expressed and conclusions arrived at, are those of the author and are not necessarily to be attributed to the sponsor.

1. Participant Information

Please indicate your answer by ticking the appropriate box. Where spaces are provided, please fill in your answer. Please answer all of the questions.

1.1 *	Organisation Name	

1.2 *	Job Title or Function	○ Business Analyst ○ Business or Line of Business Manager ○ Business Process Practitioner ○ Executive (CEO, COO, CFO) ○ HR Manager or Human

174

○ Performance Practitioner   ○ IT Manager / IT Developer   ○ Other

1.3	If other, please specify.	[ ]

1.4 *	Will your answers relate to the entire organisation or merely a function of the organisation?	○ Division ○ Entire Enterprise ○ Single Business or Functional Unit ○ Other

1.5	If other, please specify.	[ ]

1.6 *	What roles have you played in business process modelling sessions? (Select all of the relevant roles.)	☐ Admin ☐ Analyst (Not modeller) ☐ Facilitator ☐ Modeller ☐ Process Owner ☐ Other

1.7	If other, please specify.	[ ]

2. Business Process Modelling Tool Features

What features of a business process modelling tool do you perceive as being important to your organisation?

Please rank the following on a scale from 1 (not important) to 5 (very important).

2.1 *	The ability to post models on the web so that they can be widely shared.	Not important ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 Very important

2.2 *	The ability to store models and process data in a repository.	Not important ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 Very important

2.3 *	Collaborative Modelling (The ability of the tool to support multi-stakeholder collaborative modelling).	Not important ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 Very important

2.4 *	The ability of the tool to support multi-modeller collaborative modelling.	Not important ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 Very important

2.5	List any other features of a business process modelling tool which you think are important.	

3. The Benefits of Business Process Modelling

What do you perceive as being the benefits of business process modelling to your organisation?

Please rank the following on a scale from 1 (strongly disagree) to 5 (strongly agree).

3.1 *	Process Improvement (Greater ability to improve business processes).	strongly disagree ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 strongly agree
3.2 *	Understanding (Improved and consistent understanding of business processes).	strongly disagree ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 strongly agree
3.3 *	Communication (Improved communication of business processes across different stakeholder groups).	strongly disagree ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 strongly agree
3.4 *	Model-driven Process Execution (Ability to facilitate or support process automation, execution or enactment on the basis of models).	strongly disagree ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 strongly agree
3.5 *	Process Performance Measurement.	strongly disagree ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 strongly agree
3.6	List any other business process modelling benefits to your organisation.	

4. Business Process Modelling Challenges

What do you perceive as being the challenges concerned with business process modelling to your organisation?

Please rank the following on a scale from 1 (strongly disagree) to 5 (strongly agree).

4.1 *	Model Management (Issues related to the management of process models such as publication, version, variant or release management).	strongly disagree ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 strongly agree
4.2 *	Modelling Level of Detail (Issues related to the definition, identification or modelling of adequate levels of abstraction).	strongly disagree ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 strongly agree
4.3 *	Standardisation (The standardisation of process modelling approaches, methodologies, tools, methods, techniques or notations).	strongly disagree ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 strongly agree
4.4 *	Business Process Modelling Expertise (The establishment of process modelling expertise).	strongly disagree ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 strongly agree
4.5 *	Ease of Use (The complexity of business process modelling tools).	strongly disagree ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 strongly agree
4.6	List any other challenges of business process modelling to your organisation.	

5. Success Measures for Business Process Modelling

How strongly do you agree or disagree that the following are success measures of business process modelling?

Please rank the following on a scale from 1 (strongly disagree) to 5 (strongly agree).

5.1 *	Modeller's Satisfaction (This refers to the extent that the modeller perceives the goals and objectives to be met as well as the extent to which the modelling was efficient and an enjoyable experience.)	strongly disagree ○ ○ ○ ○ ○ strongly agree
		1 2 3 4 5

5.2 *	Model Use (The extent to which the model can be comprehended and applied.)	strongly disagree ○ ○ ○ ○ ○ strongly agree
		1 2 3 4 5

5.3 *	Process Model Quality (The extent to which the goals and properties of the model have been reached and fulfils the users in a way that is effective.)	strongly disagree ○ ○ ○ ○ ○ strongly agree
		1 2 3 4 5

5.4 *	User Satisfaction (The degree to which the user perceives that the model meets the underlined objectives.)	strongly disagree ○ ○ ○ ○ ○ strongly agree
		1 2 3 4 5

5.5 *	Effectiveness (The degree to which the goals and objectives are met.)	strongly disagree ○ ○ ○ ○ ○ strongly agree
		1 2 3 4 5

5.6 *	Efficiency (The skill of using minimal time and effort.)	strongly disagree ○ ○ ○ ○ ○ strongly agree
		1 2 3 4 5

5.7	List any other success factors that may be appropriate.	

6. Benefits of Collaborative BPM

In this study, the term collaborative business process modelling refers to business process modelling being

conducted by a team of modellers (more than 1 modeller) sharing or working on the same set of models in a collaborative environment.

What do you perceive as being the benefits of collaborative business process modelling to your organisation?

Please rank the following on a scale from 1 (strongly disagree) to 5 (strongly agree).

6.1 *	Increased understanding of the process amongst modellers.	strongly disagree	1	2	3	4	5	strongly agree
6.2 *	More accurate modelling since more than one modeller is involved.	strongly disagree	1	2	3	4	5	strongly agree
6.3 *	Shared ownership of the process amongst modellers.	strongly disagree	1	2	3	4	5	strongly agree
6.4 *	Confidence amongst modellers.	strongly disagree	1	2	3	4	5	strongly agree
6.5 *	Sharing ideas, opinions and different points of view between modellers.	strongly disagree	1	2	3	4	5	strongly agree
6.6 *	Brainstorming amongst modellers.	strongly disagree	1	2	3	4	5	strongly agree
6.7 *	Learning from other modellers.	strongly disagree	1	2	3	4	5	strongly agree

7. Challenges of Collaborative BPM

In this study, the term collaborative business process modelling refers to business process modelling being conducted by a team of modellers (more than 1 modeller) sharing or working on the same set of models in a collaborative environment.

What do you perceive as being the challenges concerned with collaborative business process modelling to your organisation?
Please rank the following on a scale from 1 (strongly disagree) to 5 (strongly agree).

7.1 *	Time management - people aspect (The overall business process modelling is more time consuming as more people are	strongly disagree	1	2	3	4	5	strongly agree

involved).

7.2 *	Difficulties of integrating and combining different versions of models and model changes.	strongly disagree ⊙ 1 ⊙ 2 ⊙ 3 ⊙ 4 ⊙ 5 strongly agree
7.3 *	Time management - technical aspect. (Increase in time due to syncing of model versions).	strongly disagree ⊙ 1 ⊙ 2 ⊙ 3 ⊙ 4 ⊙ 5 strongly agree
7.4 *	Technology constraints with Desktop PCs (Modellers working on their own separate PCs adds to additional overheads in merging ideas and models).	strongly disagree ⊙ 1 ⊙ 2 ⊙ 3 ⊙ 4 ⊙ 5 strongly agree
7.5 *	Not having multi-touch computers makes collaboration difficult.	strongly disagree ⊙ 1 ⊙ 2 ⊙ 3 ⊙ 4 ⊙ 5 strongly agree
7.6 *	Having different interpretations of the process from each modeller.	strongly disagree ⊙ 1 ⊙ 2 ⊙ 3 ⊙ 4 ⊙ 5 strongly agree

8. Collaborative BPM Success Factors

How important is each of the following critical success factors for collaborative business process modelling?

Please rank the following on a scale from 1 (not important) to 5 (very important).

8.1 *	User Participation (This refers to the degree of participant input, related to the specified BP.)	Not important ⊙ 1 ⊙ 2 ⊙ 3 ⊙ 4 ⊙ 5 Very important
8.2 *	Modelling Tool (The application that is used to build the model, maintain the model and distribute the model.)	Not important ⊙ 1 ⊙ 2 ⊙ 3 ⊙ 4 ⊙ 5 Very important
8.3 *	Time Resources (Collaborative modelling requires a lot of time but can lead to effective and correct models).	strongly disagree ⊙ 1 ⊙ 2 ⊙ 3 ⊙ 4 ⊙ 5 strongly agree

8.4 * Modellers giving different inputs and interpretations of the processes.

strongly disagree ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 strongly agree

8.5 * Drawing only one diagram (or a set of diagrams) and sharing input to that diagram(s).

strongly disagree ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 strongly agree

8.6 List any other success factors for collaborative business process modelling that might be appropriate.

9. Collaborative BPM Status

In this study, the term collaborative business process modelling refers to business process modelling being conducted by a team of modellers (more than 1 modeller) sharing or working on the same set of models in a collaborative environment.

To what extent do you agree or disagree with the following statements? Please rank the following on a scale from 1 (strongly disagree) to 5 (strongly agree).

In your organisation:

9.1 * In your organisation, business process modelling activities are carried out in a collaborative manner.

strongly disagree ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 strongly agree

9.2 * More than one modeller collaborates on a model or on a set of models.

strongly disagree ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 strongly agree

9.3 * Your experience with collaborative business process modelling has been positive.

strongly disagree ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 strongly agree

9.4 * List reasons/factors for why it has or has not been a positive experience.

9.5	List any challenges of collaborative business process modelling that you have faced in your organisation.	

9.6 *	You collaborate by sharing your business process models via email.	strongly disagree ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 strongly agree

9.7 *	You collaborate by sharing your business process models via an internet portal.	strongly disagree ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 strongly agree

9.8 *	Your business process modelling tool allows multiple modellers to effectively access your models.	strongly disagree ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 strongly agree

9.9 *	Your business process modelling tool allows multiple modellers to effectively update BP models each from their own device.	strongly disagree ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 strongly agree

9.10 *	List any problems that you have encountered regarding multiple modellers in a team to access or update business process models.	

10. Tools for Business Process Modelling

What technology (hardware) do you use in your organisation for collaborative business process modelling?

Please rank the following on a scale from 1 (strongly disagree) to 5 (strongly agree).

10.1 *	Multi-touch Surface	strongly disagree ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 strongly agree

| 10.2 * | Tablet PC | strongly disagree ○₁ ○₂ ○₃ ○₄ ○₅ strongly agree |

| 10.3 * | Interactive Whiteboard | strongly disagree ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 strongly agree |

| 10.4 * | Multiple displays (technologies) in a single location | strongly disagree ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 strongly agree |

| 10.5 * | Desktop PC | strongly disagree ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 strongly agree |

| 10.6 | List any other technology that you use for collaborative business process modelling. | |

Researcher: Irene   Snyman,   Email: Irene.snyman@nmmu.ac.za,   Number: 0827156653

[Submit Questionnaire]

Appendix C - Consent Form

NELSON MANDELA METROPOLITAN UNIVERSITY

INFORMATION AND INFORMED CONSENT FORM

RESEARCHER'S DETAILS	
Title of the research project	A Framework for Co-located Collaborative Business Process Modelling Using Touch Technologies
Reference number	H12-SCI-CS-019
Principal investigator	Irene Snyman
Contact telephone number (private numbers not advisable)	

A. DECLARATION BY OR ON BEHALF OF PARTICIPANT		**Initial**
I, the participant and the undersigned		

A.1 HEREBY CONFIRM AS FOLLOWS:		**Initial**
I, the participant, was invited to participate in the above-mentioned research project		
that is being undertaken by	Irene Snyman	
From the	Department of Computing Sciences	
of the Nelson Mandela Metropolitan University.		

THE FOLLOWING ASPECTS HAVE BEEN EXPLAINED TO ME, THE PARTICIPANT:	**Initial**

2.1	**Aim:**	The investigators are studying collaboration with touch technology to create and test a framework for co-located collaborative business process modelling. The information will be used to/for research purposes			
2.2	**Confidentiality:**	My identity will not be revealed in any discussion, description or scientific publications by the investigators.			
2.3	**Access to findings:**	Any new information or benefit that develops during the course of the study will be shared as follows: published in papers and thesis			
2.4	**Voluntary participation / refusal / discontinuation:**	My participation is voluntary	YES	NO	
		My decision whether or not to participate will in no way affect my present or future care / employment / lifestyle	TRUE	FALSE	

3.	No pressure was exerted on me to consent to participation and I understand that I may withdraw at any stage without penalisation.	

4.	Participation in this study will not result in any additional cost to myself.	

A.2 I HEREBY VOLUNTARILY CONSENT TO PARTICIPATE IN THE ABOVE-MENTIONED PROJECT:	
Signed/confirmed at	on 20
	Signature of witness:
Signature	Full name of witness:

Appendix D - Written Information Given to Participant Prior to Participation

Dear Participant,

You have been selected to take part in the research study carried out by Irene Snyman (researcher). The study seeks to create a framework for co-located collaborative business process modelling. This framework will aid groups of people to conduct collaborative business process modelling activities in a co-located environment by indicating how such a process should be carried out.

The researcher will provide you with relevant information describing the purpose of the study as well as your rights as a participant in this study. The researcher will also explain what is expected from you during the evaluation. Please feel free to ask questions at any time. If at any time during the evaluation, you wish to withdraw, you are welcome to do so. If any problems arise during the evaluation, please report them to the researcher immediately. The researcher will be present at all times.

This study has been approved by the Research Ethics Committee (Human) (REC-H) of the Nelson Mandela Metropolitan University. The REC-H consists of a group of independent experts that has the responsibility to ensure that the rights and welfare of participants in research are protected and that studies are conducted in an ethical manner. Studies cannot be conducted without REC-H's approval. Queries with regard to your rights as a research subject can be directed: *Research Ethics Committee (Human), Department of Research Capacity Development, PO Box 77000, Nelson Mandela Metropolitan University, Port Elizabeth, 6031.*

Your identity will remain confidential at all times; however, you might be referred to as "participant X". This research may be presented at conference proceedings or journals. If at

any time you feel uncomfortable you have the right to withdraw from the study with no penalty or loss of benefits.

Yours sincerely,

Irene Snyman

Researcher and Evaluator

Appendix E - Oral Information Given to Participant Prior to Participation

I, Irene Snyman, the Primary Investigator (PI) and Researcher will provide participants with an oral introduction. The introduction will be given in English and will include:

- The participants' rights will be given to them, indicating that they are free to withdraw from the study at any time.
- The purpose of the system that the participants will evaluate as well as the purpose for the evaluations.
- Participants will be made aware that all the results from the evaluations will be used for academic purposes only.
- What is expected from the participants during the evaluation. This includes the signing of the consent form, an oral and written introduction to the evaluation, completion of the biographical form and the post-task questionnaire.
- The basic system functionality will be explained and participants will be given a chance to familiarise themselves with the system and the setup.
- Any questions the participants might have will be answered orally by the PI.

Appendix F - Cover Letter

Subject: Request for completion of a survey for Master's research

Dear xyz,

My name is Irene Snyman and I am currently doing my MCom through the Department of Computing Sciences at the Nelson Mandela Metropolitan University (NMMU). I am currently in my final year of my MCom. I am writing a dissertation with the title: "A Framework for collaborative business process modelling using touch technologies". Business process modelling is a collaborative activity and collaborative business process modelling has not been studied in depth. The purpose of this study is to identify relevant factors that can be included in a framework for collaborative business process modelling. Upon completion of my Masters I will produce a framework that can be used for collaborative business process modelling.

I have a survey that I would like a minimum of two employees from your company to complete. The survey asks basic business process modelling questions. The results from the survey will be used to develop the initial framework for my studies. May I survey you and your fellow employees? The ideal would be to survey at least one person at management level and at least one employee. Five surveys will be greatly appreciated.

I am aware that your time is valuable and I appreciate the time used to complete the survey. Your responses will be treated with complete confidentiality and will only be used for the purposes of this study. The results will be documented in an anonymous form.

Please feel free to contact me or my promoters if you have any queries. The contact details can be seen below. You are welcome to request the survey results. If you would like a copy of the results send me an email indicating that you would like the results. Please forward this email to any fellow employees.

Follow the link below and please complete the survey:

http://forms.nmmu.ac.za/websurvey/q.asp?sid=561&k=rirdzomgqd

Thank you in advance for your participation. Your time and effort is highly appreciated.

Kind regards,

Irene Snyman

0827156653

Irene.snyman@nmmu.ac.za

Prof Andre Calitz

Andre.Calitz@nmmu.ac.za

Dr Brenda Scholtz

Brenda.Scholtz@nmmu.ac.za

Appendix G – Pilot Study Instructions

Practical Exercises

Purpose

The purpose of this exercise is to determine what participants experience when conducting business process modelling activities in a group environment. The problems of collaborative business process modelling as well as the advantages will be documented.

Instructions

Team up into groups of three and complete the exercise below. The scenario must be modelled in Enterprise Architecture. Upon completion of the task, please complete the relevant questionnaires.

Please see last page of Appendix C for Scenario and template which must <u>please be handed back to the convener once completed.</u>

Appendix H – Pilot Study Scenario

Shipment Process of a Hardware Retailer

Enterprise Architecture

Start time: ───────────────────

A clerk must ship goods. The goods must be packaged in the warehouse by the warehouse worker and the clerk must decide if the postage will be normal post or special shipment.

If the mode of delivery is normal post, the clerk must check if extra insurance is necessary. Insurance is always necessary which leads to a post label being filled in. Extra insurance can also be required which means that the logistics manager must take out extra insurance.

If the mode of delivery is special carrier, the clerk must request quotes from the carriers. (Insurance must be included in the carrier service.) The clerk must then assign a carrier and prepare the paperwork.

The warehouse worker will then add all of the relevant paperwork and move the package to the pick area. The goods are then available for picking.

End time: ───────────────────

Please complete Questionnaire A and then only complete Questionnaire B.

Appendix I - Pilot Study, Questionnaire A (BPM Course)

Please complete the questionnaire below.

Place a cross in the correct column.

	Question	True	False
1.	You were able to complete the task successfully.		

Where applicable please rank the following on a scale from 1 (strongly disagree) to 7 (strongly agree).

	Business Process Modelling	**1 Strongly Disagree**	**Disagree**	**Somewhat Disagree**	**Neutral**	**Somewhat Agree**	**Agree**	**7 Strongly Agree**	**N/A**
1.	You experienced minimal usability problems with the modelling tool								
2.	You are satisfied with your task time								
3.	You are satisfied with your overall model								
4.	You made a minimal number of errors								
5.	You understood the scenario								
6.	You were able to create a model based on the scenario								
7.	Modelling the process is an easy task								

	Collaboration	1 Strongly Disagree	Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Agree	7 Strongly Agree	N/A
1.	We worked together to model the scenario								
2.	All team members participated								
3.	Minimal mistakes were made due to collaborating with other team members								
4.	I was able to communicate to team members throughout the task with ease								
5.	My experience with collaborative business process modelling has been positive								
6.	I was able to collaborate with ease								

	Collaboration	1 Strongly Disagree	Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Agree	7 Strongly Agree	N/A
7.	Having a partner made the task of modelling the process easier								

1. How did you share the task of modelling the scenario? (What role did each member play and how did you collaborate?)

2. What problems did you have while carrying out this task collaboratively?

3. What advantages did you experience with carrying out this task collaboratively?

4. Other comments.

Appendix J - Pilot Study, Questionnaire B (BPM Course)

1. Comparing the individual modelling tasks completed earlier and the collaborative modelling task, which did you prefer and why? (Individual/Collaborative)

2. List any positive aspects of carrying out process modelling activities in a collaborative environment.

3. List any negative aspects of carrying out process modelling activities in a collaborative environment.

4. Did the tool make a difference in the experience of modelling in a collaborative environment? Explain.

5. Did you use only one computer or several computers while modelling collaboratively? Explain why.

6. Any other comments related to collaborative business process modelling.

Appendix K - Field Study, Assignment 1: Scenario

Shipment Process of a Hardware Retailer

The shipment process is triggered when the clerk sees that there are goods that need to be shipped. The goods must be packaged in the warehouse by the warehouse worker while the clerk decides what type of postage to use either normal post or special carrier.

If the type of delivery selected is normal post, the clerk must check if extra insurance is necessary. For normal post a postal label must be completed. If extra insurance is taken, then this is done by the logistics manager who must also collect the extra insurance payment.

If the mode of delivery is special carrier, the clerk must request quotes from the carriers. (Insurance must be included in the carrier service.) The clerk must then review the quotes and then assign a carrier.

Once the shipment types have been finalised, a process of authorising the shipment takes place. Lastly the package is moved to the picking area and the goods are available for shipping.

Appendix L - Field Study Instructions

Collaborative Business Process Modelling Exercise

Name:

Group Number:

Participant Number:

Purpose

The purpose of this exercise is to determine what participants experience when conducting business process modelling activities in a group environment. The problems of collaborative business process modelling as well as the advantages will be documented.

Instructions

Team up into groups of two and complete the exercise below.

- Two participants in a team.
- Record your start time (below).
- Draw the model on paper. Upon completion, present the paper based model to the evaluator. You will then receive a memo that needs to be modelled on Enterprise Architect.
- Split the model so that each participant has a part that he/she must model on their own.
- Record start time for drawing model in EA

   Start time for drawing model in EA: _____

   Each participant must then model their part of the model on their own computer in a pre-decided colour.
- Record completed time for drawing model in EA
   End time for drawing model in EA: _____
- Save your part of the model seperately under your participant number.

- Record start time for syncing model on computer

  Start time for syncing model: _____

- Combine the two separate models (indicating by two colours which participant did what) and save the final combined model under your group number. The final model should match the memo as much as possible.

- Record end time for syncing model in EA

  End time for syncing model: _____

- Record your final end time of submission (below).

- Upon completion, complete the questionnaire:

http://www.nmmu.ac.za/websurvey/q.asp?sid=1109&k=idqetmncij.

Overall start time: _____

Overall end time: _____

Appendix M - Field Study, Assignment 2: Scenario

Loan Application Process

An applicant wishes to apply for a study loan. The information of the loan application must be recorded after which it must be checked to see if it is complete. An application is complete if all information is recorded and all documents are submitted. If the application is complete the study loan will be validated. If the application is incomplete, an error message must be generated and the application is rejected.

If the application is complete the credit status of the applicant is checked. If the applicant is a current customer then the loan is approved. If the applicant is not a customer then the application must be forwarded to the credit department for authorisation.

If the authorisation is made by the credit department then the application is approved by the clerk.

If the application is approved, the clerk must send a loan approval advice to the applicant and at the same time notify the finance department.

If the application is rejected, a rejection letter must be sent to the applicant by the clerk. The process is then complete.

Appendix N - Field Study Questionnaire

WRBP Questionnaire

Page:	1

The purpose of this questionnaire is to evaluate how you modelled a business process using a business process modelling tool in a team environment.

1. Task Overview

Please indicate your answer by ticking the appropriate box. Where spaces are provided, please fill in your answer. Please answer all the questions.

1.1 *	You were able to complete the task successfully.	○ Yes ○ No

2. Business Process Modelling

Please indicate your answer by ticking the appropriate box. Where spaces are provided, please fill in your answer. Please answer all the questions.

2.1 *	You experienced minimal usability problems with the modelling tool.	strongly disagree ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 strongly agree
2.2 *	You are satisfied with your task time.	strongly disagree ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 strongly agree
2.3 *	You are satisfied with your overall model.	strongly disagree ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 strongly agree

2.4 *	You made a minimal number of errors.	strongly disagree ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 strongly agree

2.5 *	You were able to create a model using the Enterprise Architect tool.	strongly disagree ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 strongly agree

2.6 *	Modelling the process using Enterprise Architect is an easy task.	strongly disagree ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 strongly agree

3. Collaboration

Please indicate your answer by ticking the appropriate box. Where spaces are provided, please fill in your answer. Please answer all the questions.

3.1 *	All the team members participated in the modelling process.	strongly disagree ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 strongly agree

3.2 *	Minimal mistakes were made due to collaborating with other team members.	strongly disagree ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 strongly agree

3.3 *	My experience with collaborative business process modelling in this exercise has been positive.	strongly disagree ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 strongly agree

3.4 *	I was able to collaborate easily.	strongly disagree ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 strongly agree

3.5 *	Having a partner made the task of modelling easier.	strongly disagree ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 strongly agree

3.6 *	Working collaboratively using this system was not challenging.	strongly disagree ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 strongly agree

3.7 *	I can easily share ideas using this system.	strongly disagree ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 strongly agree

3.8 * I was able to easily communicate with my team member(s).

strongly disagree ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 strongly agree

4. Usability

Please indicate your answer by ticking the appropriate box. Where spaces are provided, please fill in your answer. Please answer all the questions.

4.1 * Overall, I am satisfied with how easy it is to use the system.

strongly disagree ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 strongly agree

4.2 * It was simple to use the system.

strongly disagree ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 strongly agree

4.3 * I could effectively complete the tasks and scenarios using this system.

strongly disagree ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 strongly agree

4.4 * I was able to complete the tasks and scenarios quickly using this system.

strongly disagree ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 strongly agree

4.5 * I was able to efficiently complete the tasks and scenarios using this system.

strongly disagree ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 strongly agree

4.6 * I felt comfortable using this system.

strongly disagree ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 strongly agree

4.7 * It was easy to learn to use this system.

strongly disagree ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 strongly agree

4.8 * I believe I could become productive quickly using this system.

strongly disagree ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 strongly agree

4.9 * The system gave error messages that clearly told me how to fix problems.

strongly disagree ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 strongly agree

4.10 * Whenever I made a mistake using the system, I could recover easily and quickly.

strongly disagree ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 strongly agree

4.11 * The information (such as on-line help, on-screen messages and other documentation) provided with this system was clear.

strongly disagree ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 strongly agree

4.12 * It was easy to find the information I needed.

strongly disagree ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 strongly agree

4.13 * The information provided for the system was easy to understand.

strongly disagree ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 strongly agree

4.14 * The information was effective in helping me complete tasks and scenarios.

strongly disagree ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 strongly agree

4.15 * The organisation of information on the system was clear.

strongly disagree ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 strongly agree

4.16 * The interface of was this system was pleasant.

strongly disagree ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 strongly agree

4.17 * I liked using the interface of this system.

strongly disagree ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 strongly agree

4.18 * This system has all the functions and capabilities I expect it to have.

strongly disagree ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 strongly agree

4.19 * Overall, I am satisfied with this system.

strongly disagree ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 strongly agree

5. Approaches to Collaborative BPM

Please indicate your answer by ticking the appropriate box. Where spaces are provided, please fill in your answer. Please answer all the questions.

5.1 *	One person operated Enterprise Architect and the other person provided input.	strongly disagree	○ 1	○ 2	○ 3	○ 4	○ 5	strongly agree

5.2 *	We collaborated by sharing our business process models via an internet portal.	strongly disagree	○ 1	○ 2	○ 3	○ 4	○ 5	strongly agree

5.3 *	We collaborated by sharing our business process models via email.	strongly disagree	○ 1	○ 2	○ 3	○ 4	○ 5	strongly agree

5.4	List any other ways in which you shared your models.		

6. Challenges

What challenges did you have when carrying out this task collaboratively?

Please indicate your answer by ticking the appropriate box. Where spaces are provided, please fill in your answer. Please answer all the questions.

6.1 *	We struggled to manage our time as more than one person is involved.	strongly disagree	○ 1	○ 2	○ 3	○ 4	○ 5	strongly agree

6.2 *	We struggled to integrate and combine different versions of the model.	strongly disagree	○ 1	○ 2	○ 3	○ 4	○ 5	strongly agree

6.3 *	We struggled to manage our time as the technology was difficult to use.	strongly disagree	○ 1	○ 2	○ 3	○ 4	○ 5	strongly agree

6.4 *	Not having multi-touch computers makes collaboration difficult.	strongly disagree	○ 1	○ 2	○ 3	○ 4	○ 5	strongly agree

7. Positive Aspects of Collaborative BPM

What were the positive aspects of carrying out this task collaboratively?

Please indicate your answer by ticking the appropriate box. Where spaces are provided, please fill in your answer. Please answer all the questions.

7.1 *	Increased understanding amongst modellers.	strongly disagree ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 strongly agree
7.2 *	More accurate modelling since more than one modeller is involved.	strongly disagree ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 strongly agree
7.3 *	Shared ownership of process amongst modellers.	strongly disagree ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 strongly agree
7.4 *	Increased confidence amongst modellers.	strongly disagree ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 strongly agree
7.5 *	Sharing ideas, opinions and different points of view.	strongly disagree ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 strongly agree
7.6 *	Brainstorming amongst modellers.	strongly disagree ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 strongly agree
7.7 *	Learning from other modellers.	strongly disagree ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 strongly agree

8. Positive Aspects of the Modelling Tool

Please list any positive aspects of the modelling tool.

8.1 *	Please list any positive aspects relating to the use of the modelling tool.	

9. Challenges Experienced with the Modelling Tool

Please list any challenges experienced while using the modelling tool.

9.1 ∗	Please list any challenges you had with the modelling tool.	

10. Approaches / Steps Taken

Please list the approaches you took to combine your two models into one.

10.1 ∗	Step 1 - Actions taken	

10.2 ∗	Step 2 - Actions taken	

10.3	Step 3 - Actions taken	

10.4	Step 4 - Actions taken	

10.5	Step 5 - Actions taken	

10.6	Other steps taken	

10.7 ∗	List any problems encountered while trying to combine the models.	

10.8 ∗	How did the BPM tool (EA) help or not help to combine the models?	

208

11. Other Comments

Please add any comments.

11.1   Any other comments.

12. Group Details

Please add your group number below.

12.1   Group Number
*

Researcher: Irene   Snyman,   Email: Irene.snyman@nmmu.ac.za,   Number: 0827156653

Submit Questionnaire

Appendix O - Cronbach's Alpha Values and Frequency Counts for the Field Studies

Assignment One

Item and Reliability Analysis

Section 2 - Item and Reliability Analysis

BPM (Section 2)	Item-Total Correlation	Alpha if deleted
Q2_1	0.44	0.83
Q2_2	0.83	0.75
Q2_3	0.60	0.80
Q2_4	0.66	0.79
Q2_5	0.58	0.81
Q2_6	0.51	0.82
Section 2 – Cronbach's alpha: 0.83		

Section 3 - Item and Reliability Analysis

Collaboration (Section 3)	Item-Total Correlation	Alpha if deleted
Q3_1	0.36	0.85
Q3_2	0.51	0.83
Q3_3	0.69	0.81
Q3_4	0.86	0.78
Q3_5	0.55	0.83
Q3_6	0.56	0.83
Q3_7	0.39	0.85
Q3_8	0.72	0.81
Section 3 – Cronbach's alpha: 0.84		

Section 4 - Item and Reliability Analysis

Usability (Section 4)	Item-Total Correlation	Alpha if deleted
Q4_1	0.75	0.93
Q4_2	0.76	0.93
Q4_3	0.63	0.93
Q4_4	0.83	0.93
Q4_5	0.65	0.93
Q4_6	0.77	0.93
Q4_7	0.68	0.93
Q4_8	0.65	0.93
Q4_9	0.31	0.94
Q4_10	0.31	0.94
Q4_11	0.55	0.93
Q4_12	0.68	0.93
Q4_13	0.63	0.93
Q4_14	0.68	0.93
Q4_15	0.49	0.93
Q4_16	0.61	0.93
Q4_17	0.77	0.93
Q4_18	0.61	0.93
Q4_19	0.76	0.93
Section 4 – Cronbach's alpha: 0.94		

Section 5 - Item and Reliability Analysis

(Approaches to Collaborative BPM) Section 5	Item-Total Correlation	Alpha if deleted
Q5_1	0.21	0.73
Q5_2	0.59	0.20
Q5_3	0.44	0.43
Section 5 – Cronbach's alpha: 0.59		

Section 6 - Item and Reliability Analysis

Challenges (Section 6)	Item-Total Correlation	Alpha if deleted
Q6_1	0.59	0.77
Q6_2	0.58	0.77
Q6_3	0.76	0.69
Q6_4	0.56	0.79
Section 6 – Cronbach's alpha: 0.80		

Section 7 - Item and Reliability Analysis

Positive Aspects of Collaborative BPM (Section 7)	Item-Total Correlation	Alpha if deleted
Q7_1	0.56	0.93
Q7_2	0.66	0.92
Q7_3	0.74	0.91
Q7_4	0.79	0.91
Q7_5	0.84	0.90
Q7_6	0.88	0.90
Q7_7	0.85	0.90
Section 7 – Cronbach's alpha: 0.92		

Alpha and Average Inter Item Correlation

Section 2 – Alpha and Average Inter Item Correlation

Question	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Mean	Standard Deviation
Section 2							
Q2_1	4	5	10	6	2	2.89	1.15
Q2_2	4	4	8	9	2	3.04	1.19
Q2_3	2	3	5	11	6	3.59	1.19
Q2_4	2	3	7	10	5	3.48	1.16
Q2_5	1	0	1	13	12	4.30	0.87
Q2_6	3	5	7	8	4	3.19	1.24

Section 3 – Alpha and Average Inter Item Correlation

Question	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Mean	Standard Deviation
Section 3							
Q3_1	1	0	2	3	21	4.59	0.93
Q3_2	1	2	11	8	5	3.52	1.01
Q3_3	1	1	9	8	8	3.78	1.05
Q3_4	1	2	5	11	8	3.85	1.06
Q3_5	0	1	7	9	10	4.04	0.90
Q3_6	2	3	10	7	5	3.37	1.15
Q3_7	1	4	10	8	4	3.37	1.04
Q3_8	0	1	6	6	14	4.22	0.93

Section 4 – Alpha and Average Inter Item Correlation

Question	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Mean	Standard Deviation
Section 4							
Q4_1	2	3	8	10	4	3.41	1.12
Q4_2	4	2	8	10	3	3.22	1.22
Q4_3	1	3	5	9	9	3.81	1.14
Q4_4	3	4	7	10	3	3.22	1.19
Q4_5	0	4	10	7	6	3.56	1.01
Q4_6	1	2	10	11	3	3.48	0.94
Q4_7	1	2	7	12	5	3.67	1.00
Q4_8	0	5	6	12	4	3.56	0.97
Q4_9	3	6	14	2	2	2.78	1.01
Q4_10	2	4	10	8	3	3.22	1.09
Q4_11	2	4	14	5	2	3.04	0.98
Q4_12	1	6	10	7	3	3.19	1.04
Q4_13	0	5	10	9	3	3.37	0.93
Q4_14	0	5	4	17	1	3.52	0.85
Q4_15	0	2	11	11	3	3.56	0.80
Q4_16	1	6	8	9	3	3.26	1.06
Q4_17	3	5	5	6	8	3.41	1.39
Q4_18	2	3	6	10	6	3.56	1.19
Q4_19	2	2	8	11	4	3.48	1.09

Section 5 – Alpha and Average Inter Item Correlation

Question	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Mean	Standard Deviation
Section 5							
Q5_1	10	5	5	6	1	2.37	1.31
Q5_2	12	4	4	6	1	2.26	1.35
Q5_3	9	3	5	6	4	2.74	1.51

Section 6 – Alpha and Average Inter Item Correlation

Question	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Mean	Standard Deviation
Section 6							
Q6_1	6	4	8	7	2	2.81	1.27
Q6_2	5	6	9	3	4	2.81	1.30
Q6_3	7	8	6	5	1	2.44	1.19
Q6_4	8	6	6	6	1	2.48	1.25

Section 7 – Alpha and Average Inter Item Correlation

Question	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Mean	Standard Deviation
Section 7							
Q7_1	0	1	9	14	3	3.70	0.72
Q7_2	0	1	8	13	5	3.81	0.79
Q7_3	0	0	6	14	7	4.04	0.71
Q7_4	0	0	6	14	7	4.04	0.71
Q7_5	0	0	6	10	11	4.19	0.79
Q7_6	0	0	4	13	10	4.22	0.70
Q7_7	0	1	5	10	11	4.15	0.86

Assignment Two

Item and Reliability Analysis

Section 2 - Item and Reliability Analysis

Section 2	Item-Total Correlation	Alpha if deleted
Q2_1	0.71	0.71
Q2_2	0.65	0.73
Q2_3	0.40	0.79
Q2_4	0.54	0.76
Q2_5	0.39	0.79
Q2_6	0.59	0.75
Section 2 – Cronbach's alpha: 0.79		

Section 3 - Item and Reliability Analysis

Section 3	Item-Total Correlation	Alpha if deleted
Q3_1	0.28	0.83
Q3_2	0.51	0.81
Q3_3	0.73	0.78
Q3_4	0.64	0.78
Q3_5	0.44	0.81
Q3_6	0.70	0.78
Q3_7	0.51	0.81
Q3_8	0.58	0.80
Section 3 – Cronbach's alpha: 0.82		

Section 4 - Item and Reliability Analysis

Section 4	Item-Total Correlation	Alpha if deleted
Q4_1	0.72	0.95
Q4_2	0.71	0.95
Q4_3	0.63	0.95
Q4_4	0.80	0.95
Q4_5	0.63	0.95
Q4_6	0.85	0.95
Q4_7	0.82	0.95
Q4_8	0.76	0.95
Q4_9	0.42	0.96
Q4_10	0.65	0.95
Q4_11	0.75	0.95
Q4_12	0.84	0.95
Q4_13	0.67	0.95
Q4_14	0.54	0.95
Q4_15	0.75	0.95
Q4_16	0.74	0.95
Q4_17	0.74	0.95
Q4_18	0.66	0.95
Q4_19	0.86	0.95
Section 4 – Cronbach's alpha: 0.95		

Section 5 - Item and Reliability Analysis

Section 5	Item-Total Correlation	Alpha if deleted
Q5_1	0.28	0.73
Q5_2	0.73	0.11
Q5_3	0.36	0.64
Section 5 – Cronbach's alpha: 0.62		

217

Section 6 - Item and Reliability Analysis

Section 6	Item-Total Correlation	Alpha if deleted
Q6_1	0.72	0.84
Q6_2	0.62	0.90
Q6_3	0.88	0.78
Q6_4	0.76	0.83
Section 6 – Cronbach's alpha: 0.87		

Section 7 - Item and Reliability Analysis

Section 7	Item-Total Correlation	Alpha if deleted
Q7_1	0.58	0.93
Q7_2	0.84	0.91
Q7_3	0.87	0.91
Q7_4	0.89	0.91
Q7_5	0.85	0.91
Q7_6	0.78	0.91
Q7_7	0.64	0.93
Section 7 – Cronbach's alpha: 0.93		

Alpha and Average Inter Item Correlation

Section 2 – Alpha and Average Inter Item Correlation

Question	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Mean	Standard Deviation
Section 2							
Q2_1	1	7	4	16	7	3.60	1.12
Q2_2	2	2	5	11	15	4.00	1.16
Q2_3	0	1	2	8	24	4.57	0.74
Q2_4	2	1	10	12	10	3.77	1.09
Q2_5	0	0	2	10	23	4.60	0.60
Q2_6	0	6	9	10	10	3.69	1.08

Section 3 – Alpha and Average Inter Item Correlation

Question	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Mean	Standard Deviation
Section 3							
Q3_1	0	0	2	4	29	4.77	0.55
Q3_2	1	3	6	9	16	4.03	1.12
Q3_3	0	1	6	10	18	4.29	0.86
Q3_4	1	1	5	8	20	4.29	1.02
Q3_5	1	3	1	10	20	4.29	1.07
Q3_6	1	2	9	14	9	3.80	0.99
Q3_7	3	3	6	14	9	3.66	1.21
Q3_8	0	0	6	9	20	4.40	0.77

Section 4 – Alpha and Average Inter Item Correlation

Question	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Mean	Standard Deviation
Section 4							
Q4_1	1	2	10	12	10	3.80	1.02
Q4_2	0	5	11	10	9	3.66	1.03
Q4_3	0	1	7	16	11	4.06	0.80
Q4_4	1	1	8	14	11	3.94	0.97
Q4_5	0	1	10	12	12	4.00	0.87
Q4_6	1	1	9	17	7	3.80	0.90
Q4_7	0	2	10	14	9	3.86	0.88
Q4_8	0	4	11	12	8	3.69	0.96
Q4_9	6	10	10	6	3	2.71	1.20
Q4_10	5	4	10	10	6	3.23	1.29
Q4_11	3	3	18	8	3	3.14	1.00
Q4_12	1	2	14	11	7	3.60	0.98
Q4_13	0	2	13	16	4	3.63	0.77
Q4_14	0	1	14	15	5	3.69	0.76
Q4_15	1	1	13	13	7	3.69	0.93
Q4_16	1	2	11	13	8	3.71	0.99
Q4_17	0	4	11	12	8	3.69	0.96
Q4_18	0	1	16	10	8	3.71	0.86
Q4_19	1	0	11	14	9	3.86	0.91

Section 5 – Alpha and Average Inter Item Correlation

Question	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Mean	Standard Deviation
Section 5							
Q5_1	10	3	4	10	8	3.09	1.58
Q5_2	19	5	3	5	3	2.09	1.42
Q5_3	16	5	3	2	9	2.51	1.70

Section 6 – Alpha and Average Inter Item Correlation

Question	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Mean	Standard Deviation
Section 6							
Q6_1	10	10	10	4	1	2.31	1.11
Q6_2	10	7	6	7	5	2.71	1.45
Q6_3	12	6	13	3	1	2.29	1.13
Q6_4	10	9	11	5	0	2.31	1.05

Section 7 – Alpha and Average Inter Item Correlation

Question	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Mean	Standard Deviation
Section 7							
Q7_1	0	0	7	16	12	4.14	0.73
Q7_2	0	1	6	15	13	4.14	0.81
Q7_3	0	0	8	13	14	4.17	0.79
Q7_4	0	0	6	16	13	4.20	0.72
Q7_5	0	0	6	13	16	4.29	0.75
Q7_6	0	1	6	8	20	4.34	0.87
Q7_7	1	1	4	11	18	4.26	0.98

Appendix P - Cronbach's Alpha Values for BPM Survey

Cronbach's Alpha Values for Various Sections of the Survey

Section	Cronbach's alpha
The Benefits of BPM	**0.82**
BPM Challenges	**0.80**
Success Factors for BPM	**0.71**
Benefits of CBPM	**0.89**
Challenges of CBPM	**0.73**
CBPM Success Factors	**0.64**
CBPM Status	**0.79**

Appendix Q - Post-test Questionnaire for the BPMTouch Evaluation

Collaborative Business Process Modelling Evaluation (BPMTouch)

Page:	1

The purpose of this questionnaire is to document your opinion of the software prototype and the framework that you have evaluated. Your identity will remain anonymous at all times. Please answer all of the questions as accurately and descriptive as possible. Thank you for your time and effort.

1. Biographical Information

Please complete the section regarding your biographical information.

1.1 *	Age	○ 18 - 25 ○ 26 - 35 ○ 36 - 45 ○ > 45

1.2 *	Male or Female	○ Male ○ Female

1.3 *	Number of years' experience with computers.	○ < 1 ○ 1 - 5 ○ 6 - 10 ○ > 10

1.4 *	Number of years' experience with touch devices.	○ < 1 ○ 1 - 5 ○ 6 - 10 ○ > 10

1.5 *	Number of years' experience with BPM and BP concepts.	○ < 1 ○ 1 - 5 ○ 6 - 10 ○ > 10

223

1.6 *	Do you have business process modelling experience?	○ Yes ○ No

1.7 *	Do you have experience in other modelling such as UML?	○ Yes ○ No

2. Task Overview

Please indicate your answer by selecting the appropriate radio button.

2.1 *	You were able to complete the BPM task.	○ Not at all ○ Partially ○ Successfully

2.2 *	You are satisfied with the time taken to complete the task.	very dissatisfied ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 very satisfied

2.3 *	You had enough time to complete the task.	strongly disagree ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 strongly agree

3. Collaboration

Please indicate your answer by selecting the appropriate radio button.

3.1 *	All the team members participated in the modelling process.	strongly disagree ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 strongly agree

3.2 *	Minimal mistakes were made due to collaborating with other team members.	strongly disagree ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 strongly agree

3.3 *	My experience with collaborative business process modelling in this exercise has been	strongly disagree ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 strongly agree

	positive.		
3.4 *	I was able to collaborate easily.	strongly disagree ○ 1 ○ 2 ○ 3 ○ 4 ○ 5	strongly agree
3.5 *	Having a partner made the task of modelling easier.	strongly disagree ○ 1 ○ 2 ○ 3 ○ 4 ○ 5	strongly agree
3.6 *	I can easily share ideas using this system.	strongly disagree ○ 1 ○ 2 ○ 3 ○ 4 ○ 5	strongly agree
3.7 *	I was able to easily communicate with my team member(s).	strongly disagree ○ 1 ○ 2 ○ 3 ○ 4 ○ 5	strongly agree

4. Usability

Please indicate your answer by selecting the appropriate radio button.

4.1 *	Overall, I am satisfied with how easy it is to use the system.	strongly disagree ○ 1 ○ 2 ○ 3 ○ 4 ○ 5	strongly agree
4.2 *	It was simple to use the system.	strongly disagree ○ 1 ○ 2 ○ 3 ○ 4 ○ 5	strongly agree
4.3 *	I could effectively complete the tasks and scenarios using this system.	strongly disagree ○ 1 ○ 2 ○ 3 ○ 4 ○ 5	strongly agree
4.4 *	I was able to complete the tasks and scenarios quickly using this system.	strongly disagree ○ 1 ○ 2 ○ 3 ○ 4 ○ 5	strongly agree
4.5 *	I was able to efficiently complete the tasks and scenarios using this system.	strongly disagree ○ 1 ○ 2 ○ 3 ○ 4 ○ 5	strongly agree
4.6 *	I felt comfortable using this system.	strongly disagree ○ 1 ○ 2 ○ 3 ○ 4 ○ 5	strongly agree

4.7 *	It was easy to learn to use this system.	strongly disagree ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 strongly agree
4.8 *	I believe I could become productive quickly using this system.	strongly disagree ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 strongly agree
4.9 *	The system gave error messages that clearly told me how to fix problems.	strongly disagree ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 strongly agree
4.10 *	Whenever I made a mistake using the system, I could recover easily and quickly.	strongly disagree ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 strongly agree
4.11 *	The information provided with this system was clear.	strongly disagree ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 strongly agree
4.12 *	It was easy to find the information I needed.	strongly disagree ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 strongly agree
4.13 *	The information provided for the system was easy to understand.	strongly disagree ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 strongly agree
4.14 *	The information was effective in helping me complete tasks and scenarios.	strongly disagree ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 strongly agree
4.15 *	The organisation of information on the system was clear.	strongly disagree ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 strongly agree
4.16 *	The interface of this system was pleasant.	strongly disagree ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 strongly agree
4.17 *	I liked using the interface of this system.	strongly disagree ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 strongly agree

4.18 * This system has all the functions and capabilities I expect it to have.

strongly disagree ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 strongly agree

4.19 * Overall, I am satisfied with this system.

strongly disagree ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 strongly agree

5. Challenges

Please indicate your answer by selecting the appropriate radio button.

5.1 * We struggled to manage our time as more than one person is involved.

strongly disagree ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 strongly agree

5.2 * We struggled to integrate our models.

strongly disagree ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 strongly agree

5.3 * We struggled to manage our time as the technology was difficult to use.

strongly disagree ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 strongly agree

6. Gesture Manipulation

Please indicate your answer by selecting the appropriate radio button.

6.1 * The system correctly interpreted the gestures used.

strongly disagree ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 strongly agree

6.2 * The objects were large enough to allow for touch.

strongly disagree ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 strongly agree

6.3 * The gestures were logical and easily remembered.

strongly disagree ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 strongly agree

6.4 *	It was easy to interact with the system using the gestures.	strongly disagree ◯ 1 ◯ 2 ◯ 3 ◯ 4 ◯ 5 strongly agree

6.5 *	Having touch computers made collaboration easier.	strongly disagree ◯ 1 ◯ 2 ◯ 3 ◯ 4 ◯ 5 strongly agree

7. Best Features of the Modelling Tool

Please list the best features the modelling tool.

7.1 *	Please list three positive aspects of the modelling tool.	

8. Negative Feature of the Modelling Tool

Please list any negative features of this modelling tool.

8.1 *	Please list three negative aspects of the modelling tool.	

9. PC versus Touch

For collaborative business process modelling, do you prefer a standard system that runs on a PC (Enterprise Architect, visio etc.) or the touch prototype running on the tablet.

9.1 *	Do you prefer a traditional PC system or the Touch?	◯ Traditional PC System ◯ BPMTouch - Touch Technology

9.2 *	Give a reason for your selection.	

10. Other Comments

Please fill in all of the questions where spaces are provided.

10.1   Any other comments.

Researcher: Irene Snyman, Email: Irene.snyman@nmmu.ac.za, Number: 0827156653

Submit Questionnaire

Appendix R – BPMTouch Evaluation Task List

Collaborative Business Process Modelling Exercise

Name:

Group Number:

Participant Number:

Purpose

The purpose of this exercise is to determine what participants experience when conducting business process modelling activities in a group environment. The problems of collaborative business process modelling as well as the advantages will be documented.

Instructions

- Two participants in a team.
- Start time for drawing model in ProcessCraft: _____
- Draw the model that you have received on ProcessCraft, making use of two Tablet PCs. Upon completion, save the model and present the model to the evaluator.
- Record completed time for drawing the model in ProcessCraft. End time for drawing model in ProcessCraft: _____
- Upon completion, complete the questionnaire:

http://forms.nmmu.ac.za/websurvey/q.asp?sid=1181&k=jhlugyjaun

Appendix S – BPM Survey (Organisation Questions)

Business Process Modelling (BPM) Survey (Organisation Questionnaire)

Page:	**1**

The purpose of this survey is to gather data from organisations to find out what they are doing in terms of business process modelling and workflow. The data gathered from this survey will be used anonymously to contribute towards the design of a framework for co-located collaborative business process modelling. The framework will be used to aid groups of people to conduct process modelling activities simultaneously in a co-located environment. The data collected from this survey will be treated strictly confidential. The data will not be used for any other purpose than for conducting the research and writing the dissertation for academic purposes only. The results will be displayed anonymously and no participant's identity will be revealed. Your cooperation and time to participate in this survey is greatly appreciated. Note: This is a confidential questionnaire. Your identity will not be revealed. Your willingness to participate is most appreciated. Feedback will be provided to all participants upon request. This research is being conducted in fulfilment of the requirements for the degree Magister Commercii (100% research) in Computing Sciences at Nelson Mandela Metropolitan University. The financial assistance by the NRF and NMMU Master's bursaries towards this research is hereby acknowledged. The opinions expressed and conclusions arrived at, are those of the author and are not necessarily to be attributed to the sponsor.

1. Organisation Related

Please indicate your answer by ticking the appropriate box. Where spaces are provided, please fill in your answer. Please answer all the questions.

1.1 *	Organisation Name	
1.2 *	What is the size of your organisation?	○ < 100 Employees ○ 100 - 500 Employees ○ > 500 Employees
1.3 *	In which industry do you work?	○ Aerospace / Defence ○ Chemicals / Energy ○ Computers / Consumer /

231

Electronics / Software ○ Distribution / Supply

○ Chain ○ Education Financial Services / Insurance ○ Food /

○ Beverage ○ Government / Military ○ Healthcare / Medical ○ Heavy

○ Manufacturing Leisure / Entertainment / Travel Light

○ Manufacturing Retail and

○ Wholesale ○ Telecommunications ○ Utilities Other

1.4	If other, please specify.	

1.5 * In which province is your office located?

○ Gauteng ○ KwaZulu -

Natal Limpopo ○ Mpumalanga ○ North ○ West Eastern

○ Cape ○ Free State ○ Northern Cape ○ Western Cape ○ Outside South Africa

1.6 * Approximately how many employees are involved with business process modelling in your organisation?

○ < 5 Employees ○ 5 - 20 Employees ○ > 20 Employees

1.7 * Do you do business process modelling in a collaborative environment?

○ Yes ○ No

1.8 * Explain your reason for modelling collaboratively or not collaboratively.

1.9 * Select the software tools used at your organisation for process modelling.

○ A process modelling tool that is part of a BPM suite ○ A standalone process

○ modelling tool ○ Microsoft Visio ○ Enterprise Architect ○ Don't use any

○ software tool to create or save process models Other

1.10	If other, please specify.	

1.11 * Which modelling notations and standards are you using for business process modelling?

☐ BPEL ☐ BPMN ☐ UML ☐ XPDL ☐ Other

	(Select all the notations that apply).	
1.12	List any other modelling notations and standards that you use.	
1.13 *	Do you carry out business process modelling in your organisation or do you model business processes for other organisations?	☐ Model in our organisation for our organisation. ☐ Model for other organisations. ☐ Other.
1.14	If other, please specify.	

2. Roles in Business Process Modelling

What roles are involved in business process modelling in your organisation?

Please indicate if the role exists within your organisation.

2.1 *	Expert Modeller	○ Yes ○ No ○ Don't know
2.2 *	Business Analyst	○ Yes ○ No ○ Don't know
2.3 *	Facilitator	○ Yes ○ No ○ Don't know
2.4 *	Process Owners	○ Yes ○ No ○ Don't know
2.5 *	Observers	○ Yes ○ No ○ Don't know
2.6	List other stakeholders in your organisation who are involved in the modelling process.	

233

3. Evaluation Feedback

If you would like feedback on the results of the study, please provide your details below.

3.1   Email Address:

Researcher: Irene   Snyman,   Email: Irene.snyman@nmmu.ac.za,   Number: 0827156653

Submit Questionnaire

Appendix T – SAICSIT Paper

The Usability of Collaborative Tools: Application to Business Process Modelling Tools

Brenda Scholtz
NMMU
Dept of Computing Sciences
Port Elizabeth, S.A.
+27 41 504 2079
brenda.scholtz@nmmu.ac.za

Andre Calitz
NMMU
Dept of Computing Sciences
Port Elizabeth, S.A.
+27 41 504 2639
andre.calitz@nmmu.ac.za

Irene Snyman
NMMU
Dept of Computing Sciences
Port Elizabeth, S.A.
+27 41 504 2639
irene.snyman@nmmu.ac.za

ABSTRACT

Modelling the business processes of an organisation offers benefits such as improved communication, increased understanding of processes, support for change management and gaining of competitive advantage over other organisations. However, Business Process Modelling (BPM) in large projects often needs to be carried out collaboratively in a team environment. The benefits of collaborative modelling are a reduced workload for modellers and improved quality, readability and accuracy of models. The result is also increased understanding of the processes amongst team members. Traditional technologies and BPM tools have several usability problems and often do not allow for effective collaboration and integration of business process models.

Touchscreens are becoming the standardised modality of mobile devices such as smart phones and tablet PCs. This paper investigates the use of collaborative business process modelling (CBPM) software and hardware for improving the usability of CBPM projects. A BPM software prototype was designed which allows the drawing of business process (BP) models using touch and also enables the synchronous display of the process model on multiple tablet PCs. A field study comprised of two assignments was carried out to evaluate the difficulties of CBPM with traditional BPM tools running on desktop PCs.

Categories and Subject Descriptors

H.5.2 [Information Interfaces and Presentation]: User Interfaces – evaluation/methodology, interaction styles, User-centered design

K.3.2 [Computers and Education]: Computer and Information

Science Education – *Computer Science Education, Curriculum.*

General Terms
Collaborative. Business Process Modelling. Touch Technology.

Keywords
Business Process Modelling, Collaboration, Touch Technology.

1. INTRODUCTION

Business process modelling (BPM) plays an important role in decision making as well the daily operations of organisations. BPM forms part of the field of business process management and is a major step in the business process life cycle. In order for BPM to be successful, it often needs to be undertaken in a collaborative environment in which all the required stakeholders are present [1, 2, 3]. This collaborative nature of BPM can pose several challenges. These challenges include the fact that multiple stakeholders are involved, that process owners have a different understanding of the process than that of the modeller and time management challenges due to the number of stakeholders involved [1].

The International Standards Organisation (ISO) provides guidance on usability, documented in 1998 (ISO 9241-11) [4]. Usability refers to the degree to which a product can be used by a specific group of people in a particular context, to achieve predetermined goals with satisfaction, effectiveness and efficiency. Satisfaction refers to how happy the user is with the completed task, effectiveness refers to task completeness and efficiency refers to the effort needed in order to complete the task [5]. In this study the concept of collaborative usability refers to the way in which collaboration can aid in the satisfaction, effectiveness and efficiency of modelling a BP.

Traditional BPM tools also do not allow for effective collaborative work. Smaller mobile touch devices, such as the tablet PC could allow for effective collaborative work as participants are able to work on the device without being positioned behind a large PC screen. The sales of tablet PCs are

also predicted to surpass those of desktop PCs and notebooks by 2017. This paper investigates the usability of BPM tools used for collaborative modelling purposes, with particular focus on the task of integrating business process (BP) models. Touch technology is investigated as a possible solution for Collaborative Business Process Modelling (CBPM). Studies in the field of BPM primarily focus on the management aspects and research in the area of CBPM is limited. This paper therefore fills a gap in this area of research and provides a valuable contribution to the field of CBPM.

The research methodology and research questions are discussed in Section 2. Several research studies relating to BPM and collaboration are presented in Section 3. A literature review of touch technologies and their collaborative features was undertaken in order to investigate their feasibility as possible BPM tools and the results are presented in Section 4. A field study of CBPM was carried out with second year Information Systems (IS) students enrolled for a BPM course and the results of the field study are presented and analysed in Section 5. The results of the literature review and the field study were used to assist with the design of a proposed CBPM application using touch technology (BPMTouch) and this design is presented in Section 6. Several conclusions and recommendations of the paper are presented in Section 7.

2. RESEARCH METHODOLOGY

The primary aim of this paper is to investigate the usability of traditional BPM software tools using desktop PCs with particular focus on the collaborative tasks involved with BP modelling in team environments. A secondary aim of the paper is to investigate the use of touch technology for CBPM tasks and to propose the BPMTouch. The research problem to be addressed by this paper is that traditional software tools do not support easy collaboration and touch input for BPM. BP modellers are often required to work on BP models in teams. However, the collaboration features supported by traditional BPM tools using desktop PCs does not allow modellers to work on a BP model simultaneously and modellers have to overcome several challenges with regards to integrating and syncing these BP models. The research problem is that students working in teams in BPM courses are required to perform CBPM tasks. In this study, the term CBPM refers to BPM being conducted by a team of modellers sharing process models or working on the same set of models in a collaborative environment.

In order to address the research problem of this paper several research questions (RQ) were identified, namely:

RQ1: What are the benefits of CBPM?

RQ2: What are the challenges of CBPM?

RQ3: How do students rate the collaborative usability of traditional BPM software tools using desktop PCs?

RQ4: How can touch technology be used to support CBPM tasks?

ISO 9126 also identifies five sub-characteristics of usability including attractiveness, operability, usability compliance, learnability and understandability [6]. Other usability metrics include task success, efficiency, effectiveness, satisfaction, learnability and self-reported metrics [5].

Self-reported metrics have been identified by [5] as a usability metric which can be used for measuring CBPM. Accuracy has also been identified as a benefit and metric for CBPM [1], and so has sharing ideas [7]. Communication is a factor that needs to be taken into consideration when carrying out tasks collaboratively [8], as well as ease of collaboration. All of these metrics form part of the collaborative usability metrics of this study and can therefore be used to measure usability (Figure 1).
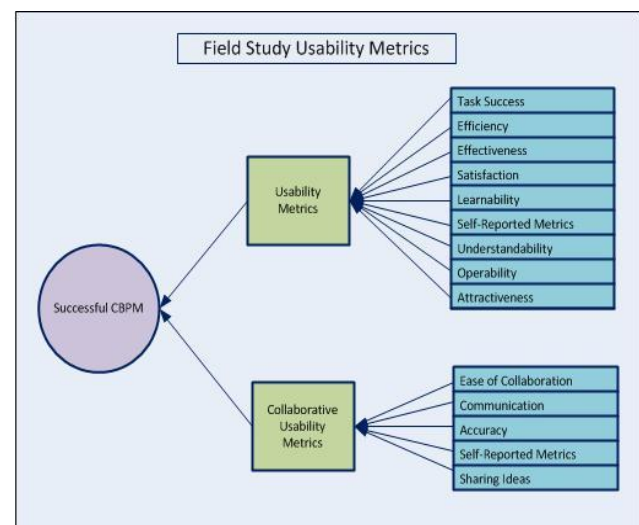
Figure 1: Collaborative usability metrics

The research strategies used to answer the research questions include a field study comprising of two separate assignments, a literature review and the design and development of a software prototype. The questionnaire was validated by means of a pilot study and from interviews with several BPM experts where several challenges and approaches to CBPM were identified. RQ1 is answered based on an in-depth literature review. RQ2 and RQ3 are addressed by a field study of two BPM course assignments using BPM software on desktop PCs. RQ4 is answered by a combination of a literature review and the development of a software prototype. This paper forms part of a larger study whereby the prototype will undergo further evaluation and validation.

For the two assignments, second year Information Systems (IS) undergraduate students registered for the Business Process Modelling module were used. They were required to draw BP models in the BPM software Enterprise Architect (EA) in traditional computer laboratories using desktop PCs. These tasks formed part of their practical assignments for the course. Students were required to work in teams of two students per team and to give feedback regarding their experience with BPM in

collaborative environments using the EA software and desktop PCs. Prior to the assignment the students were given a lecture on the Business Process Model and Notation (BPMN), a BPM notation which they used to model their scenarios with an introductory lecture on the EA software.

The instructions provided were that each member of the team had to participate equally in the drawing of the model using EA and that the team had to submit one integrated model. Each student had to complete a post-test questionnaire consisting of usability and collaborative usability metrics (Figure 1). The post-test questionnaire comprised of seven sections with Likert scale ratings of 1 to 5, where 1 indicates that participants *"Strongly Disagree"* and 5 indicates that participants *"Strongly Agree"* with the statement.

3. BUSINESS PROCESS MODELLING (BPM) AND COLLABORATION SOFTWARE

A business process (BP) can be referred to as a set of actions carried out in order to achieve a goal [9, 10]. BPs are activated when an event occurs in the business [11]. Upon activation of the process, many business rules are followed in order to complete the BP. A business process model is a diagram describing a business process [9]. These models can be created for various reasons: management might not fully understand the process and a model can be created to aid in the understanding of the process or models can provide the specifications necessary to automate or improve business processes. The type of information conveyed in a model depends on the target audience who will be using the model. The primary benefits of using BPM in organisations are increased control and consistency and improved operational effectiveness [12]. Other reported benefits of BPM include:

- Improved communication [7, 8];

- Improvement of business processes [13];

- Improved understanding of business processes [13];

- Increased re-use of designed processes [13]; and

- Support for change management [13].

There are many different traditional BPM tools on the market today, for example:

- UModel: Allows for the creation of stand-alone BP models or the incorporations of business rules into a development project [14].

- Enterprise Architect (EA): An enterprise wide solution that caters for the entire life cycle including collaborative modelling, analysing, visualising, testing and maintaining systems, processes and software [15]. EA is a popular BPM software tool which caters for designing and creating software, BPM and general modelling [16]. Over 300 000 EA licences have been sold world-wide and it has become the preferred UML modelling tool for analysts, consultants and software developers in 130 countries.

- Microsoft Visio: Microsoft Visio caters for the easy creation of professional diagrams including flowcharts, IT networks, organisation charts, BP models and floor plans [17].

- AccuProcess Modeler: BPM software that aids users in designing, documenting, improving and simulating BPs [18].

- Bizagi Process Modeler: Freeware that can be used for the creation of BP models [19]. Bizagi also has a business process management suite which caters for the automation of BPs.

BPM is a collaborative activity in industry as multiple people work together and are needed to create successful business process models [1]. It is essential for the key stakeholders to be present in a BPM session to promote accurate modelling, shared ownership of the processes and an improved understanding of the processes amongst the key stakeholders. Humans are social beings and thrive in environments in which they can connect with other human beings [20]. Collaboration refers to the act of working together [21] and it can be either dispersed or co-located [5, 6]. Dispersed collaboration is collaboration that takes place while participants are not in the same room. Co-located collaboration refers to collaboration that occurs while participants are sharing a location [22]. Collaboration, dispersed and co-located, can also comprise of synchronous (face-to-face) or asynchronous (bulletin boards, electronic mail) communication [23]. The key benefits for collaboration reported by [24] are quicker response times; decreased chances of making mistakes and improved transparency and responsibility. Additional benefits were also reported by [25] such as improved decision making and higher quality of creativity.

The participants that should be present in a CBPM environment include: process owners, a business analyst, a session facilitator, a modelling expert, observers and any other relevant stakeholders [1]. Brainstorming and learning from others has been reported by [26] as a primary benefit of collaboration. Other reported benefits of CBPM identified by [1] is the shared understanding amongst modellers, increased accuracy of BP models, shared ownership of BP models and confidence amongst process owners.

4. COLLABORATIVE HARDWARE

Large multi-touch surfaces (Figure 2) are technologies than promote collaboration as they allow for multiple users to simultaneously interact with data on the screen [27]. Participants can use their fingers, instead of a keyboard and mouse, to make gestures on the screen and these touch input gestures are then interpreted by the software and results are presented on the screen. Multi-touch surfaces allow for an intuitive experience as input and output are provided on the same surface [28]. Participants interacting around a large multi-touch surface can make decisions together and share ideas or concerns on the surface. The multi-touch surface provides participants with many benefits including: seeing participants' body languages, individuals can point to objects on the screen and address concerns and all of the other participants will be able to interact [29].

Multi-touch surfaces allow users to interact with the data using their fingers and a participant's fingers is easier to follow that a mouse cursor on a large screen [28]. These surfaces can reduce the time and cost of collaboration efforts. Multi-touch surfaces are also considered a good technology for collaboration as it involves multiple individuals working on and around a large table and humans have been collaborating around tables for decades [30]. Various design implications need to be taken into consideration when designing software for a multi-touch surface, such as: marking territories for each participant, taking the orientation of objects into consideration and the access to objects on the surface.
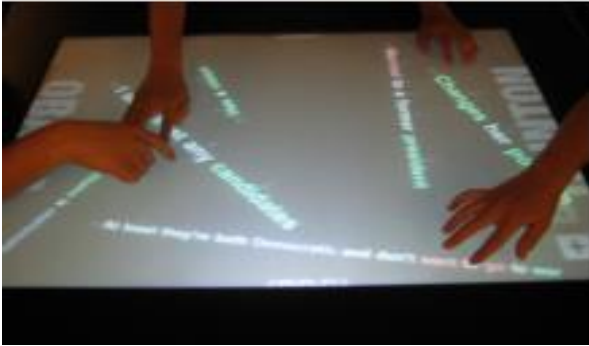

Figure 2: An example of a large multi-touch surface [31]

Interactive whiteboards (IWB), traditional whiteboards and blackboards are also technologies that support collaboration. The IWB allows participants to interact directly with the whiteboard [32] eliminating the need of the traditional keyboard and mouse. The desktop PC is controlled directly from the whiteboard. Benefits of IWBs include: being able to prepare, access and modify saved work, access and display multimedia, multiple participant involvement and direct feedback. These IWBs are popular in classroom environments as students can interact with the teacher and the IWB and they receive immediate feedback. It has also been proven that students are less self-conscious and not afraid to make mistakes [7]. IWBs however have several limitations: it is an expensive technology, users need to be trained before using it, it is time consuming to learn, the IWB must be well maintained, it needs to be installed by a professional and it is immobile [32].

An alternative to IWBs is the tablet PC [26]. Tablet PCs (Figure 3) can also be used in a classroom environment by wirelessly connecting the tablet to a projector. In this way the teacher can walk around and engage with the students while working on the tablet and students can then see the projected results. The advantages of tablets are that they are less expensive than IWBs and are more versatile and are mobile. However, the response of a tablet can be slower than that of the IWB if the environment has a slow wireless connection.

Tablet PCs make use of touch input with either a finger or a stylus and the output is provided on the same surface. The input provided to tablets is similar to the input provided to large multi-touch surfaces in that they both recognise gestures and provide feedback based on the gestures. Stitching is a synchronous gesture that uses a pen to connect different mobile devices [33].

The gesture comprises of a pen that spans over several screens, creating a shared work space (Figure 3).
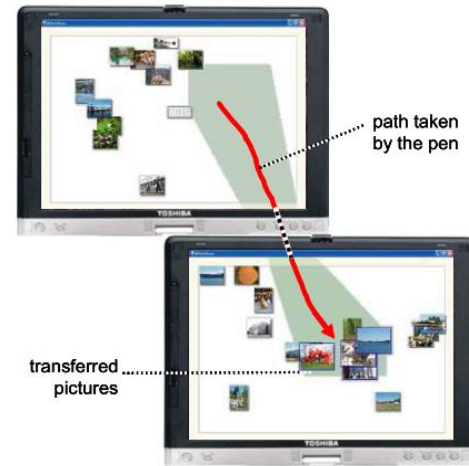
Figure 3: An example of two tablet PCs [34].

Gartner predicts that the shipment of tablets will surpass the shipment of desktop PCs and notebooks by 72% by the year 2017 [34]. In the year 2017, 467 951 000 tablets will be shipped worldwide (Figure 4). The benefits of tablets include: portability; mobility; support for video and audio; robust and improved communication [26]. Other advantages of tables reported are that the work can be saved, accessed and edited at different times and that several people can focus on a tablet concurrently, thereby facilitating easy collaboration [33, 34]. Tablets are also therefore easy to use for team work, in meetings, are comfortable to use and functional [35].

Device Type	2012	2013	2014	2017
PC (Desk-Based and Notebook)	341,263	315,229	302,315	271,612
Ultramobile	9,822	23,592	38,687	96,350
Tablet	116,113	197,202	265,731	467,951
Mobile Phone	1,746,176	1,875,774	1,949,722	2,128,871
Total	2,213,373	2,411,796	2,556,455	2,964,783

Figure 4: Shipment of devices worldwide (thousands of units) [34]

Tablets also have limitations such as: the cost is higher than laptops with better specifications, challenging to use outside in the light, the battery life is short, boot up time is slow and the use of tablets can be restricted by poor networks [26]. Tablets also do not have physical keyboards, not all corporate software can run on tablets, advanced multimedia editing cannot be performed on tablets and tablets need to be replaced every few years [36]. Other tools that cater for collaboration include videoconferencing,

data presentation, e-calendars, application sharing, workflow systems, knowledge management systems and project management tools [24]. However, these tools are not suitable for BPM tasks.

5. FIELD STUDY RESULTS

The participant profile consisted of 37 students who form part of the second year BPM class, of which 26 were Males and 11 were Females. This is representative of a typical IS undergraduate course. For each assignment participants were provided with a questionnaire consisting of 12 sections (S1-S12) which they had to complete. However, for various reasons, not all the students completed the questionnaire. In the first assignment 27 participants completed the questionnaire and in the second assignment 35 participants completed the questionnaire. Item reliability for the questionnaire was established since the sections on BPM tool usability (S2), Collaboration (S3), Usability (S4), Challenges (S6) and Benefits of CBPM (S7) in the questionnaire have Cronbach Alpha ratings between 0.79 and 0.94 (Appendix A) which is acceptable [37]. The section on Approaches to CBPM scored a Cronbach Alpha of 0.59 for assignment one and 0.62 for assignment two which is slightly below the accepted standard of 0.7 but still acceptable in an initial study. The mean for each closed-ended Likert scale item was classified according to the following ranges:

- *Strongly disagree (1.0 $\geq \mu <$ 1.8)*
- *Disagree (1.8 $\geq \mu <$ 2.6)*
- *Neutral (2.6 $\geq \mu \leq$ 3.4)*
- *Agree (3.4 $> \mu \leq$ 4.2)*
- *Strongly agree (4.2 $> \mu \leq$ 5.0)*

The general usability metrics for the EA BPM tool used in this study include task success, efficiency, effectiveness, satisfaction, learnability and self-reported metrics (Figure 1). The results for task success were positive for both assignments since 100% of the participants completed the task successfully. Efficiency was a subjective measurement of satisfaction of task time and was Neutral ($\mu = 3.04$) for the first assignment but in the Agree range ($\mu = 4.00$) for the second assignment (Figure 5). Participants were also satisfied with the use of EA since the results were in the "Agree" range for satisfaction of the models drawn in EA during assignment 1 ($\mu = 3.59$) and assignment 2 ($\mu = 4.57$). The participants also Agree that they made minimal errors using EA during assignment 1 ($\mu = 3.48$) and assignment 2 ($\mu = 3.77$). The item with the highest mean in the BPM tool usability section was effectiveness (*Able to create a model using the EA tool*) for both the first assignment *($\mu = 4.30$)* and for the second assignment ($\mu = 4.60$), both of which are in the Strongly Agree range indicating that EA was effective in both assignments. The item with the lowest mean is operability (*Minimal usability problems with the modelling tool*) for assignment one *($\mu = 2.89$)* and for the second assignment ($\mu = 3.60$). It can be deduced therefore that usability problems were encountered in both assignments. The second lowest rated usability item was ease of use (*Modelling using EA is easy*) for assignment 1 *($\mu = 3.19$)* and assignment 2 *($\mu = 3.69$)*.

All of the metrics increased from the first assignment to the second assignment which is to be expected due to the learning effect.
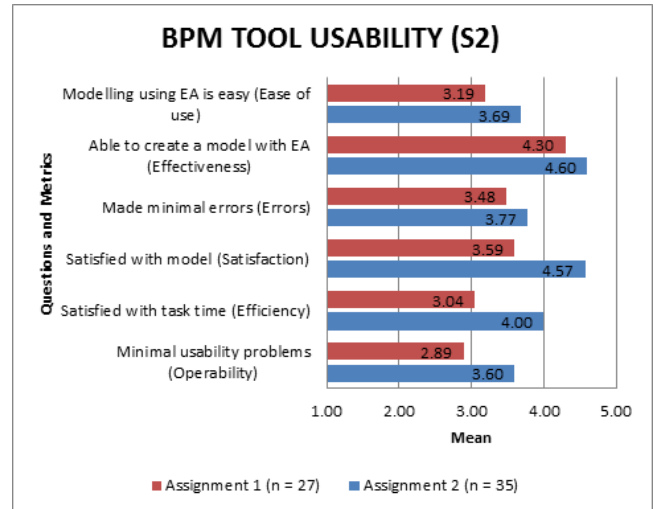
Figure 5: BPM tool usability for EA.

The collaboration usability metrics used in the questionnaire were ease of collaboration, communication, accuracy, sharing ideas and self-reported metrics (Figure 1). The results for these are shown in Figure 6. Two items in the collaborative usability section had the same mean and were the lowest for assignment 1 ($\mu = 3.37$) and were ease of collaboration (*Working collaboratively using this system was not challenging*) and share ideas (*I can easily share ideas using this system*). The item with the highest mean was item participation (*All the team members participated in the modelling process*) for both assignment 1 ($\mu = 4.59$) and for assignment 2 ($\mu = 4.77$) which are both in the Strongly agree range. These results indicate that both of the participants in each team participated however, they might have incurred challenges due to working collaboratively. The lowest mean ($\mu = 3.66$) for the collaborative usability of EA for assignment 2 was for share ideas (*I can easily share ideas using this system*), which was also one of the lowest rated items in assignment one.

Figure 6: Collaborative usability of EA.

The lowest mean value in the detailed usability section was for item operability (*Clear error messages*) for both assignment 1 ($\mu = 2.87$) and for assignment 2 ($\mu = 2.71$) and are both in the Neutral range (Figure 7). The item with the highest mean value was item effectiveness (*I could complete tasks effectively using this system*), for both assignment 1 ($\mu = 3.81$) and assignment 2 ($\mu = 4.06$) which is in the Agree range. This indicates that participants could complete the task effectively; however, they did not feel that the EA system provided clear error messages.
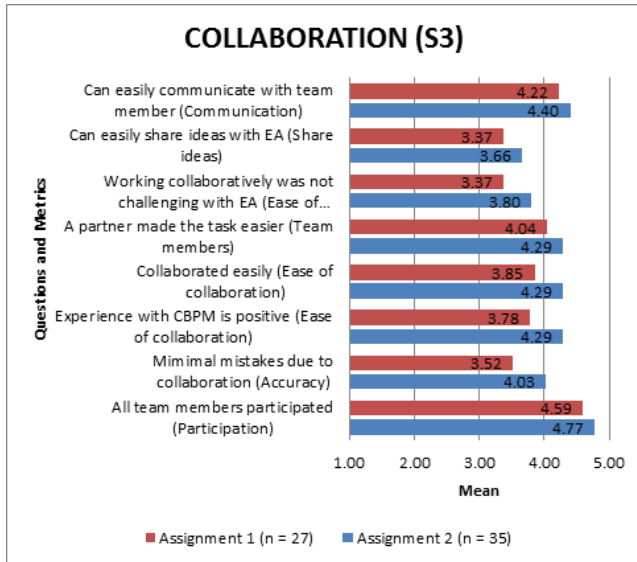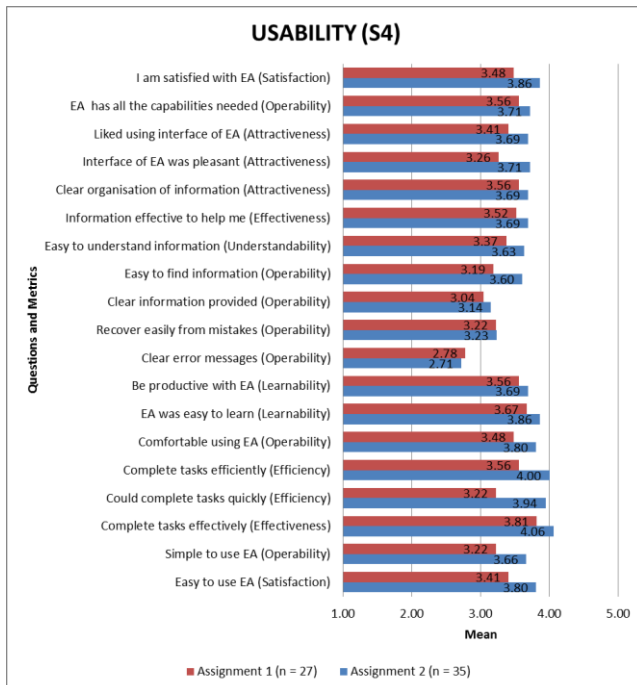

Figure 7: Detailed usability criteria.

The mean ratings for each aggregated usability metric was calculated and compared between assignment 1 and 2 (Table 1). The mean values for all of the metrics for both assignments can be classified into the Neutral and Agree range. The highest rated usability metric for assignment 1 was effectiveness whilst for assignment 2 it was efficiency. The lowest rated usability metric for assignment 1 was operability whilst for assignment 2 it was satisfaction. None of the metrics had overall mean ratings in the Disagree or Strongly disagree range and none of the metrics had a rating of four or higher.

Metrics	μ (Assignment 1)	μ (Assignment 2)	Std Dev
Operability	*3.21*	3.83	0.44
Satisfaction	3.44	*3.41*	0.03
Effectiveness	**3.67**	3.87	0.15
Efficiency	3.39	**3.97**	0.42
Learnability	3.61	3.77	0.12
Understandability	3.37	3.63	0.19
Attractiveness	3.41	3.70	0.21

Table 1: Overall usability metrics of assignment 1 and 2 (S4)

Several approaches to CPBM were identified in literature and the pilot study. These were used for the item metrics in Section 5 of the questionnaire (Figure 8). The first approach identified in the pilot study was to collaborate by sharing the model via email, whilst the second approach used the internet to share models. In the third approach one member of the team used the EA software whilst the other member verbally provided input.

Figure 8: Approaches to CBPM.

The self-reported metrics related to the additional approaches in which participants shared their models. Participants were asked to report on the steps they took to integrate their model. Several participants reported that they struggled with integrating their

different models and the majority of participants used the *XML Import and Export* function in order to achieve this task. EA has a built in importing a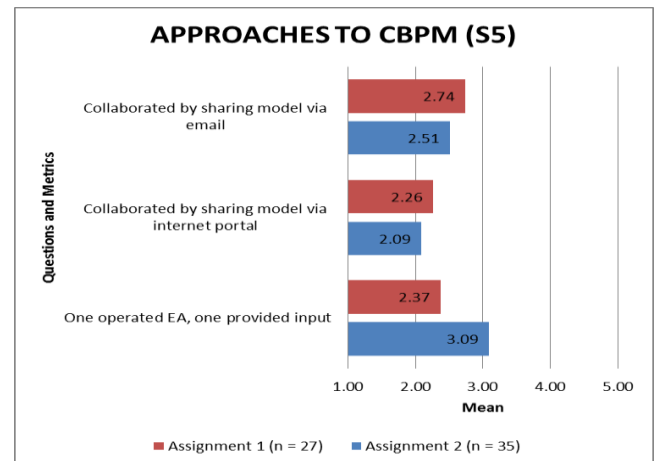nd exporting mechanism which allows for standard XMI file imports and exports [16]. The majority of the teams used this import and export function in EA to combine their two separate models. One member of the team would save his/her work and then export it in XML format to a location where the export can be saved. The exported file was then copied to the second team member's PC via a flash drive, or email. The second participant then imported the XML solution into their current solution.

All of the items in the Challenges section (S6) were compiled from the literature review and the pilot study. However the results indicated a low support for these challenges since they all had a mean value of less than or equal to 2.81 for assignment 1 and 2.71 for assignment 2 which means that they were all in the Neutral, Disagree or Strongly disagree range (Figure 9). The drop from assignment 1 to assignment 2 in the maximum mean for Challenges could be due to the learning effect principle, since it was the second EA assignment for the students.
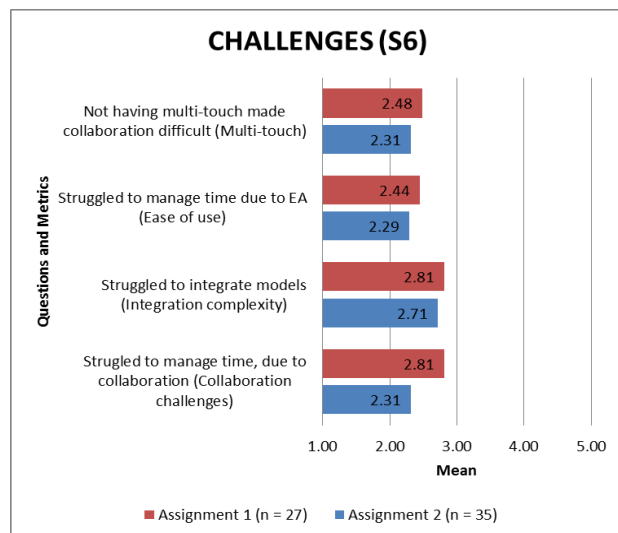

Figure 9: CBPM challenges.

The item with the highest mean in the Benefits of CBPM section was communication (*Brainstorming amongst modellers*) for both assignment 1 ($\mu = 4.22$) and assignment 2 ($\mu = 4.34$) which are both in the Strongly Agree range (Figure 10). This confirms the findings of [26] which reported brainstorming as a benefit of collaboration. The lowest mean ($\mu = 3.70$) in the benefits section of the questionnaire is understandability for assignment 1 (*Increased understanding amongst modellers*). Even though it is the lowest mean it is still in the Agree range. In assignment 2 there were two items with the same lowest mean ($\mu = 4.14$) and these were understandability (*Increased understanding amongst modellers*), and accuracy (*More accurate modelling since more than one modeller is involved*). This confirms the benefit of shared understanding amongst modellers in CBPM reported by [1]. In the second assignment all of the means are in the Strongly

Agree range therefore participants validated each benefit of CBPM as identified in the literature review.
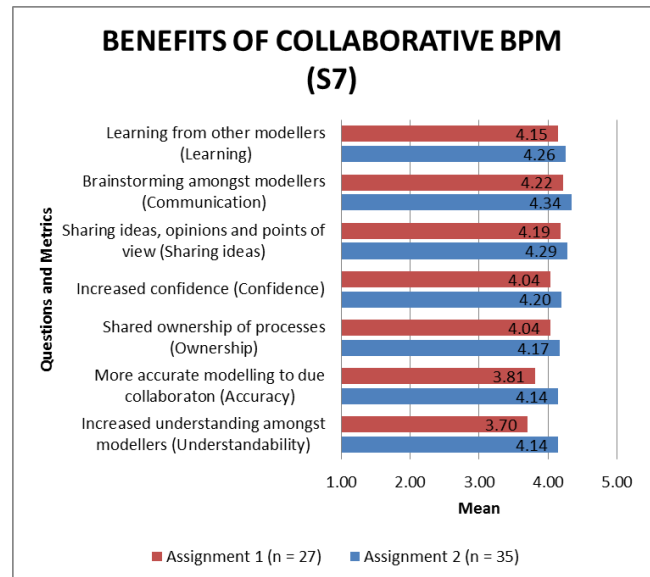
Figure 10: Benefits of CBPM.

The self-reported metrics included the benefits and challenges related to the collaborative aspects of BPM encountered using EA. The participants were also asked open-ended questions relating to the benefits and challenges relating to the use of EA. Some of the positive aspects cited by participants include: "*Powerful*", "*EA has everything needed to create a BP model*" and "*EA is easy to learn and understand*". However, the majority of participants found EA easy to use and several participants stated that they could easily become productive using EA. The majority of the participants indicated that EA was easy to learn and easy to understand. Several participants stated that: "*it is easy to use*", "*mistakes can be easily undone*", "*straight forward and easy to interpret*" and "*it is easy to draw*". This confirms [16] reporting that EA is user friendly and easy to use. The challenges reported by participants primarily related to the integration of the models. One participant reported that he/she had problems with "*positioning the objects correctly*", whilst another reported that problems were encountered with the "*integration of models*". A few participants reported that EA was not user friendly. Complaints about EA comprised mainly of the alignment of objects on the screen, resizing, moving objects around and EA not being user friendly.

Some participants indicated that the collaboration part of EA and the combining of their models was a difficult and tedious task. Sample comments made by participants were that "*collaboration of the work was tedious*", "*combining the models was difficult*", "*exporting and importing was not easy*" and "*collaboration of the two separate models was difficult*".

6. THE WAY FORWARD

Higher education institutions are investigating means to ensure that their students have access to mobile technologies which can aid teaching and learning. Tablet PCs allow for co-located and dispersed collaboration and the mobility of these devices is a large benefit. Traditional software does not support touch for BPM or mobility, whilst mobile devices do (Section 1). Tablets can therefore be used as a suitable technology for the implementation of software supporting CBPM environments as they are mobile and can be used in most environments. Tablets have also been proven to work in collaborative environments (Section 4). The proposed BPMTouch solution facilitates touch technology on several tablets whereby the BPM software is updated in real time between the tablets. In this way, multiple modellers can interact with the software while being able to see the changes made to models by the other modellers in a team. Only one modeller can make changes to the model at a time, however, all modellers can see the changes being made. If participants are in a co-located environment, they can collaborate by talking to each other and the technology aids the collaboration as participants do not have to sit behind desktop PC screens.

The BPMTouch software was initially developed by Tabtou and is known as ProcessCraft. It is a BPM tool developed for Android tablets. The code was modified so that it allows for multiple users to interact with the software from several tablets, instead of only single user. The software prototype developed will cater for a minimum of two modellers to model on separate Tablet PCs simultaneously while working together (Figure 11).
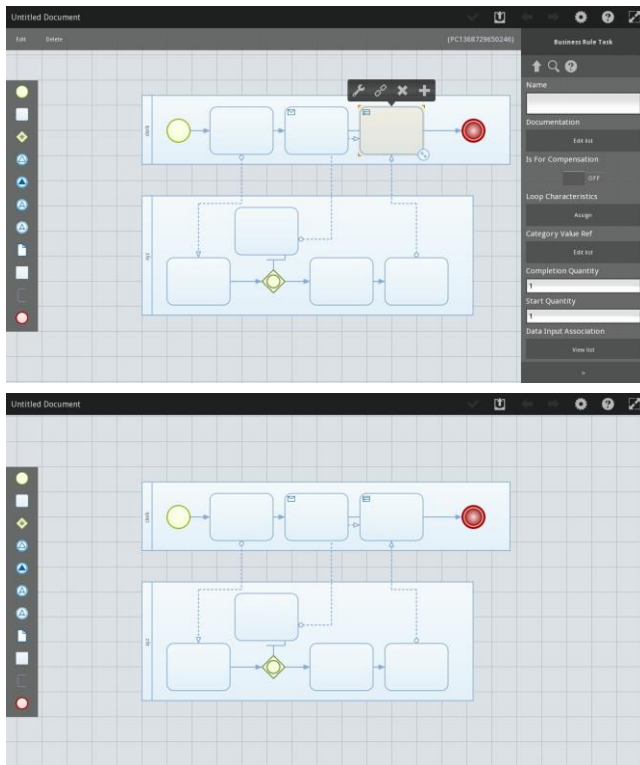

Figure 11: Example of the BPMTouch prototype

One tablet acts as a server and any additional tablets act as clients. The clients have to connect to the server by entering the server's IP address when requested. Once the client(s) are connected to the server, all users can collaborate and share one model. If a user wishes to edit the model, he/she needs to select the flag. This will show other users that someone is modelling and they will not have access to the flag until the current user has finished modelling and released the flag again. The other users will however be able to see what the current modeller is changing on the model as the changes occur. This software overcomes most of the problems and challenges identified (Section 5).

A pilot study was carried out to test the prototype. The results of the pilot study indicated that the software is stable and working as expected. Participants indicated that they preferred the touch technology over EA as it allowed for easier collaboration. The participants agreed that having a partner made the task of modelling easier and that minimal mistakes were made due to collaborating with other team members. The participants did not find the system challenging and they were able to complete the tasks efficiently.

7. CONCLUSIONS AND FUTURE RESEARCH

This paper makes several valuable contributions. Firstly empirical evidence of the benefits of CBPM is provided which supports the studies of [1] and [26]. Several additional benefits and challenges were also identified. Empirical studies of the benefits and challenges of CBPM are limited and this paper fills the gap in this regards. Research question 1 relating to the benefits of CBPM was therefore successfully answered. In addition an in-depth understanding of the problems and challenges faced by students with team and CBPM is provided. Metrics for evaluating CBPM usability were proposed and successfully used to evaluate the EA BPM software tool which was used from desktop PCs. The quantitative results showed that students were fairly satisfied with the usability of EA. Research question 2 was answered by an analysis of the findings of the field studies which indicated that the usability of EA as rated by the students was positive overall. However in terms of collaboration the qualitative results revealed that students found several challenges with integrating and syncing their separate models into one model.

The results of these field studies were used to motivate the design and development of the BPMTouch prototype which incorporates touch technology using Tablets. An analysis of the feedback from the two assignments highlighted the multiple steps involved with integrating and syncing BP models in team environments. Tablet PCs were chosen for the proposed prototype as they provide users with many benefits such as mobility, improved communication and robustness. The use of touch technology as a potential environment for CBPM was investigated and the fourth research question addressed. The BPMTouch prototype allows participants to interact with the tablet and to make and see changes as they happen on two or more different tablets. This will overcome the integration issues faced by the BPM students as the participants

will be working on one model and don't need to manually integrate the model.

This paper is part of a larger study whereby the BPMTouch prototype will be developed further and empirically validated in several experiments. The research will document the results of the empirical study as well as suggest ways of improving the prototype based on the usability results. Other future research could also include the evaluation of the prototype in other educational environments as well as in organisations who employ BP modellers that work in collaboratively in teams.

8. REFERENCES

[1]   J. Barjis, "CPI Modeling: Collaborative, Participative, Interactive Modeling," in *Proceedings of the 2011 Winter Simulation Conference*, 2011, Barjis 2009, pp. 3094–3103.

[2]   P. Rittgen, "COMA: A Tool for Collaborative Modeling.," in *Proceedings of the Forum at the CAiSE'08 Conference*, 2008, pp. 61 – 64.

[3]   E. Poppe, R. A. Brown, J. C. Recker, and D. M. Johnson, "A Prototype Augmented Reality Collaborative Process Modelling Tool," in *9th International Conference on Business Process Management*, 2011, pp. 1–5.

[4]   Usability Net, "International Standards for HCI and Usability," 2006. [Online]. Available: http://www.usabilitynet.org/tools/r_international.htm. [Accessed: 17-Jun-2013].

[5]   T. Tullis and B. Albert, *Measuring the User Experience*, 1st Editio. Burlington, MA: Morgan Kaufmann Publishers, 2008, p. 315.

[6]   M. F. Bertoa and A. Vallecillo, "Usability metrics for software components," *J. Syst. Softw.*, vol. 4, no. 2, 2006, pp. 1–10.

[7]   M. Northcote, P. Mildenhall, L. Marshall, and P. Swan, "Interactive whiteboards : Interactive or just whiteboards?," *Australas. J. Educ. Technol.*, vol. 26, no. 4, pp. 494–510, 2010.

[8]   L. Denise, "Collaboration vs. C-Three (Cooperation, Coordination, and Communication)," *Innovating*, vol. 7, no. 3, 2010, pp. 1–6.

[9]   P. Harmon, *Business Process Change*, 2nd ed. San Francisco, California, U.S.A.: Morgan Kaufmann Publishers, 2007, p. 549.

[10]   R. K. L. Ko, "A Computer Scientist's Introductory Guide to Business Process Management (BPM)," *Crossroads*, vol. 15, no. 4, ACM, 2009, pp. 11–18.

[11]   U. Dayal, M. Hsu, and L. Rivka, "Business process coordination: State of the art, trends, and open issues," in *Proceedings of the 27th VLDB Conference*, 2001, pp. 9–13.

[12]   AccuProcess, "Five Key Benefits of Business Process Modeling." , 2009, pp. 1–8.

[13]   M. Indulska, P. Green, J. Recker, and M. Rosemann, "Business process modeling: perceived benefits," in *28th International Conference on Conceptual Modeling*, 2009, November, pp. 9–12.

[14]   ALTOVA, "UModel - UML Tool for Software Modeling and Application Development," 2013. [Online]. Available: http://www.altova.com/umodel.html. [Accessed: 17-Jun-2013].

[15]   Sparx Systems, "Visual Modeling Platform," 2013. [Online]. Available: http://www.sparxsystems.com/products/ea/index.html. [Accessed: 29-May-2013].

[16]   Sparx Systems, "Enterprise Architect 10 Reviewer's Guide.", 2013, p. 33.

[17]   Microsoft, "Visio Top Features," 2013. [Online]. Available: http://office.microsoft.com/en-us/visio/microsoft-visio-2013-top-features-diagram-software-FX103796044.aspx. [Accessed: 21-Oct-2013].

[18]   AccuProcess, "Process Modeler," 2013. [Online]. Available: http://www.accuprocess.com/products/process-modeler.html. [Accessed: 17-Jun-2013].

[19]   Bizagi, "Bizagi Process Modeler," 2013. [Online]. Available: http://www.bizagi.com/index.php?option=com_content&view=article&id=335&Itemid=267&lang=en. [Accessed: 17-Jun-2013].

[20]   K. Hinckley, "Synchronous gestures for multiple persons and computers," in *Proceedings of the 16th annual ACM symposium on User interface software and technology*, 2003, pp. 149–158.

[21]   Webster's Online Dictionary, "Webster's Online Dictionary," 2012. [Online]. Available: http://www.websters-online-dictionary.org/. [Accessed: 27-Apr-2012].

[22]   Oxford University Press, "Oxford Dictionaries," 2013. [Online]. Available: http://oxforddictionaries.com/. [Accessed: 24-Mar-2013].

[23] C. A. Ellis, S. J. Gibbs, and G. L. Rein, "Groupware: some issues and experiences," *Commun. ACM*, vol. 34, no. 1, 1991, pp. 39–58.

[24] M. Butler, "The Business Value of Collaboration," London, UK, 2009.

[25] M. Maginn, *Making Teams Work*, 1st Editio. McGraw-Hill, 2004, p. 48.

[26] P. Twinning, D. Evans, D. Cook, J. Ralston, I. Selwood, A. Jones, J. Underwood, G. Dillon, E. Scanlon, S. Heppell, A. Kukulska-Hulme, P. McAndrew, and K. Sheehy, "Tablet PCs in schools." Coventry, 2004, pp. 1–12.

[27] D. Kammer, J. Wojdziak, M. Keck, R. Groh, and S. Taranko, "Towards a Formalization of Multi-touch Gestures," in *ACM International Conference on Interactive Tabletops and Surfaces*, 2010, pp. 49–58.

[28] E. Hornecker, P. Marshall, N. S. Dalton, and Y. Rogers, "Collaboration and Interference: Awareness with Mice or Touch Input," in *Proceedings of the ACM 2008 conference on Computer supported cooperative work - CSCW '08*, 2008, pp. 167–176.

[29] P. Clifton, A. Mazalek, and J. Sanford, "SketchTop: design collaboration on a multi-touch tabletop," in *Proceedings of the fifth international conference on Tangible, embedded, and embodied interaction*, 2011, pp. 333–336.

[30] S. Scott, M. Sheelagh, and T. Carpendale, "Territoriality in collaborative tabletop workspaces," in *CSCW '04 Proceedings of the 2004 ACM conference on Computer supported cooperative work*, 2004, pp. 294–303.

[31] S. Hunter and P. Maes, "WordPlay: A table-top interface for collaborative brainstorming and decision making," in *Proceedings of IEEE Tabletops and Interactive Surfaces*, 2008, pp. 2–5.

[32] Becta ICT Reserach, "Getting the most from your interactive whiteboard." British Educational Communications and Technology Agency, Coventry, 2004, pp. 1–36.

[33] K. Hinckley, G. Ramos, and F. Guimbretiere, "Stitching: pen gestures that span multiple displays," in *Proceedings of the working conference on Advanced visual interfaces*, 2004, pp. 23–31.

[34] J. Cox, "Gartner: Tablet shipments to outstrip PCs by 72% in 3 years," 2013. [Online]. Available: http://www.networkworld.com/news/2013/040413-gartner-tablets-268397.html. [Accessed: 14-May-2013].

[35] A. McMahon, "Top 10 Benefits Of Tablet PCs," 2013. [Online]. Available: http://www.businesscomputingworld.co.uk/top-10-benefits-of-tablet-pcs/. [Accessed: 19-Jun-2013].

[36] D. Reisinger, "The Problem with Tablets: 10 Things They Can't Do," 2011. [Online]. Available: http://www.channelinsider.com/c/a/Spotlight/The-Problem-with-Tablets-10-Things-They-Cant-Do-774256/. [Accessed: 19-Jun-2013].

[37] Institute for Digital Research and Education, "SPSS FAQ. What does Cronbach's alpha mean?," 2013. [Online]. Available: http://www.ats.ucla.edu/stat/spss/faq/alpha.html. [Accessed: 08-Jun-2013].

APPENDIX A

ASSIGNMENT 1 Cronbach Alpha		
S2 Average inter-item corr.: 0.47		
	Itm-Totl Correl.	**Alpha if deleted**
Q2_1	0.44	0.83
Q2_2	0.83	0.75
Q2_3	0.60	0.80
Q2_4	0.66	0.79
Q2_5	0.58	0.81
Q2_6	0.51	0.82
Cronbach alpha: 0.83		
S3 - Average inter-item corr.: 0.42		
	Itm-Totl Correl.	**Alpha if deleted**
Q3_1	0.36	0.85
Q3_2	0.51	0.83
Q3_3	0.69	0.81
Q3_4	0.86	0.78
Q3_5	0.55	0.83
Q3_6	0.56	0.83
Q3_7	0.39	0.85
Q3_8	0.72	0.81
Cronbach alpha: 0.84		
S4 - Average inter-item corr.: 0.46		
	Itm-Totl Correl.	**Alpha if deleted**
Q4_1	0.75	0.93
Q4_2	0.76	0.93
Q4_3	0.63	0.93
Q4_4	0.83	0.93
Q4_5	0.65	0.93
Q4_6	0.77	0.93
Q4_7	0.68	0.93
Q4_8	0.65	0.93
Q4_9	0.31	0.94

	Itm-Totl Correl.	**Alpha if deleted**
Q4_10	0.31	0.94
Q4_11	0.55	0.93
Q4_12	0.68	0.93
Q4_13	0.63	0.93
Q4_14	0.68	0.93
Q4_15	0.49	0.93
Q4_16	0.61	0.93
Q4_17	0.77	0.93
Q4_18	0.61	0.93
Q4_19	0.76	0.93
Cronbach alpha: 0.94		
S5 Average inter-item corr.: 0.34		
	Itm-Totl Correl.	**Alpha if deleted**
Q5_1	0.21	0.73
Q5_2	0.59	0.20
Q5_3	0.44	0.43
Cronbach alpha: 0.59		
S6 Average inter-item corr.: 0.52		
	Itm-Totl Correl.	**Alpha if deleted**
Q6_1	0.59	0.77
Q6_2	0.58	0.77
Q6_3	0.76	0.69
Q6_4	0.56	0.79
Cronbach alpha: 0.80		
S7 Average inter-item corr.: 0.66		
	Itm-Totl Correl.	**Alpha if deleted**
Q7_1	0.56	0.93
Q7_2	0.66	0.92
Q7_3	0.74	0.91
Q7_4	0.79	0.91
Q7_5	0.84	0.90
Q7_6	0.88	0.90
Q7_7	0.85	0.90
Cronbach alpha: 0.92		

ASSIGNMENT 2 Cronbach Alpha		
S2 - Average inter-item corr.: 0.39		
	Itm-Totl Correl.	**Alpha if deleted**
Q2_1	0.71	0.71
Q2_2	0.65	0.73
Q2_3	0.40	0.79
Q2_4	0.54	0.76
Q2_5	0.39	0.79
Q2_6	0.59	0.75
Cronbach alpha: 0.79		
S3 - Average inter-item corr.: 0.40		
	Itm-Totl Correl.	**Alpha if deleted**
Q3_1	0.28	0.83
Q3_2	0.51	0.81
Q3_3	0.73	0.78
Q3_4	0.64	0.78
Q3_5	0.44	0.81
Q3_6	0.70	0.78
Q3_7	0.51	0.81
Q3_8	0.58	0.80
Cronbach alpha: 0.82		
S4 - Average inter-item corr.: 0.55		
	Itm-Totl Correl.	**Alpha if deleted**
Q4_1	0.72	0.95
Q4_2	0.71	0.95
Q4_3	0.63	0.95
Q4_4	0.80	0.95
Q4_5	0.63	0.95
Q4_6	0.85	0.95
Q4_7	0.82	0.95
Q4_8	0.76	0.95
Q4_9	0.42	0.96
Q4_10	0.65	0.95
Q4_11	0.75	0.95
Q4_12	0.84	0.95
	Itm-Totl	**Alpha if**

	Correl.	**deleted**
Q4_13	0.67	0.95
Q4_14	0.54	0.95
Q4_15	0.75	0.95
Q4_16	0.74	0.95
Q4_17	0.74	0.95
Q4_18	0.66	0.95
Q4_19	0.86	0.95
Cronbach alpha: 0.95		
S5 - Average inter-item corr.: 0.39		
	Itm-Totl Correl.	**Alpha if deleted**
Q5_1	0.28	0.73
Q5_2	0.73	0.11
Q5_3	0.36	0.64
Cronbach alpha: 0.62		
S6 - Average inter-item corr.: 0.68		
	Itm-Totl Correl.	**Alpha if deleted**
Q6_1	0.72	0.84
Q6_2	0.62	0.90
Q6_3	0.88	0.78
Q6_4	0.76	0.83
Cronbach alpha: 0.87		
S7 - Average inter-item corr.: 0.68		
	Itm-Totl Correl.	**Alpha if deleted**
Q7_1	0.58	0.93
Q7_2	0.84	0.91
Q7_3	0.87	0.91
Q7_4	0.89	0.91
Q7_5	0.85	0.91
Q7_6	0.78	0.91
Q7_7	0.64	0.93
Cronbach alpha: 0.93		